CHEMICAL & METALLURGICAL ENGINEERING

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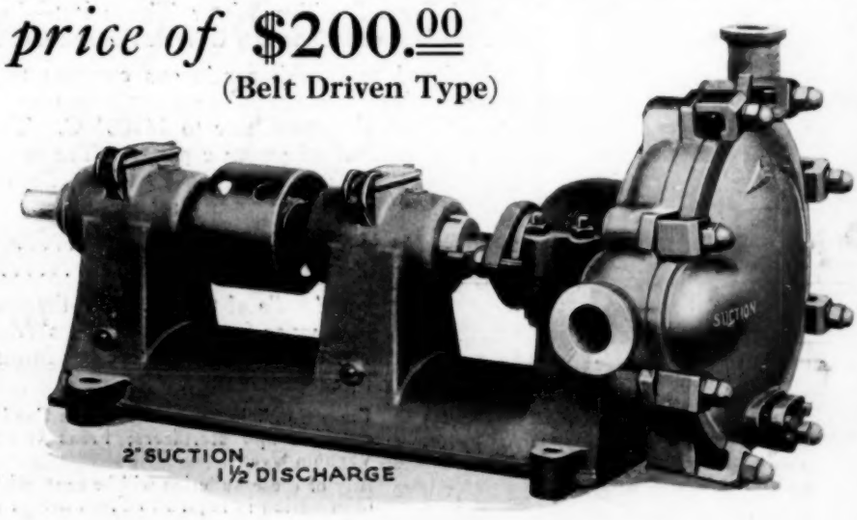

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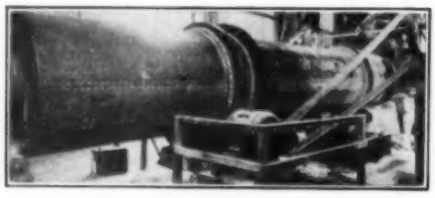

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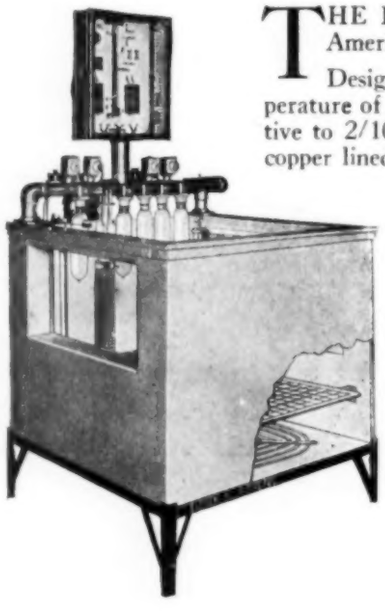

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Administrative and Business Opinions on Tariff Policy

TARIFF, always much in the public eye, is just now directly in the spotlight of legislative, administrative and business interest. With the resumption of Congressional sessions, the Senate resumes its hearings on the tariff bill; the President in his message to Congress comments at length upon the tariff situation; and the Chamber of Commerce of the United States begins to take the vote of its member organizations on a referendum regarding seven important recommendations as to tariff policy. Surely no one can say that the subject is being neglected.

In one important particular the message of the President and the recommendations of the tariff policy committee of the national Chamber of Commerce agree—namely, that there should be a flexibility for administrative regulation of tariff rates. Speaking to this point, the President recommends obtaining flexibility through "the extension of the powers of the Tariff Commission so that it can adapt itself to a scientific and wholly just administration of the law." The committee recommendation is: "Legislation should permit, in the event of changes of economic factors, adjustment of tariff rates by administrative authorities within limits prescribed by Congress for the purpose of maintaining a consistent tariff policy," and the committee also recommends "creation of a tariff adjustment board to administer adjustable rates."

Although not identical in phrasing or in implication of the agency which should administer an adjustable or flexible tariff rate, both of these recommendations recognize what is now clearly established as a fact, that we cannot arbitrarily today fix a tariff rate for many commodities without almost certainly encountering great disadvantage therefrom within the next few years, if indeed not within the next few months. There clearly is now established in the minds of many the belief that the principal economic facts and laws must sooner or later govern tariff adjustments and that the system of political tariff revision to suit the constituencies of the most influential legislators is in the long run, even for these particular constituencies, a bad policy.

In another particular the comment of the President and the recommendations of the Chamber of Commerce committee agree in part at least—namely, with respect to the proposal of "American valuation" of imports. The President points out that an arbitrary adoption of this basis of duties would be hazardous. But the Chamber of Commerce committee, with only one dissenting vote out of the twelve committeemen, recommends that "the present system of valuation for levy of ad valorem duties should be maintained and the so-called American valuation should not be adopted."

It is more and more coming to be realized that tariff protection is not an unmixed blessing even to those industries which are "protected." The opportunities existing for interruption of foreign trade by protective tariff rates fixed on anything like a rigid or permanent basis is too great to be risked at the present time. All agree that anti-dumping legislation of some type is essential, and that reasonable protection for American industries subject to destructive competition will be of general benefit to the country whenever those industries are on a sound economic footing; but even the most ardent advocates of protection are now apparently beginning to waver in their advocacy of general high protective rates. Industries that have been counting upon such rates must, therefore, begin to put their house in order for living on a different basis.

Senate to Investigate The Dye Industry

WE ARE to be regaled with a Senate investigation of the dye industry in the United States in an effort to discover monopoly on the part of American manufacturers and alleged lobbying and other nefarious activities on the part of importers of German dyes and their agents. Senator KING of Utah introduced the original resolution, which provided only for ferreting out the domestic monopoly, but Senator FRELINGHUYSEN of New Jersey shrewdly brought sufficient pressure to bear on the Senator from Utah to make him accept an amendment to extend the investigation to the so-called German dye lobby. Of course, Senator MOSES of New Hampshire supported the original King resolution and demonstrated by means of a large map suspended from the public gallery the extent of the control exercised by the alleged American monopoly in this country. Curiously enough, the center of this control was a large red spot marking the location of Wilmington, Del., with the word "du Pont" printed in the center of the red circle. It has become habit with Senator MOSES to see red whenever the dye business is mentioned, and he could readily be counted upon to join in the chase.

Thus the whole dye business in this country is to be laid bare to public gaze and we have Senator FRELINGHUYSEN to thank for making the investigation comprehensive. Like most investigations, it will probably engage in needless excursions into unrelated subjects, but we express the hope that even though the Senatorial committee may get off the track, American dye manufacturers will insist on keeping the two purposes clearly in mind so that we may know beyond a doubt whether there is a domestic dye monopoly and a perniciously active lobby of agents of German dye manufacturers.

It is not improbable that the dye embargo will come in for its share of the discussion, and we urge upon American manufacturers the merit of considering ways and means for placating the opponents of the embargo by suggesting the appointment of a board of review with an impartial chairman whose duty it shall be to determine when the embargo should be enforced. There is no doubt that it will be impossible to get a tariff law

high enough to keep out German dyes. It is equally certain the embargo will be the only effective measure, but its opponents must be given assurance that it can and will be administered fairly and efficiently. For our part we welcome the investigation and doubt not that American dye manufacturers will welcome it also if it is sincerely conducted.

Ceramic Engineers Develop Clay Industries

DISCUSSIONS of an industry by those who have a broad view of the field are apt to contain statements far more sweeping than actual facts justify. For instance, it is often said that while the art of burning clay has been practiced for many centuries the application of science in ceramic industries is woefully lacking. Now this is true in measure, particularly if the research phase in pure science is considered. We do have much to learn about colloids, plasticity, electrochemical effects and the eutectics of clay mixes in the burning. But so are other industries in the adolescence of youth as regards scientific fundamentals.

Ceramic engineers, though only recently so named, are the true technologists. They have never failed to come forward when needed on plant problems. They were the first to use regeneration and recuperation in burning processes. During the French Revolution they developed continuous firing. The American chemist developed architectural terra cotta to a stage where the Wrigley and Woolworth type of building is an accomplished fact. Optical glass production, originally centered at Jena, has been surpassed in quantity and quality in America. Further examples might be given of recent work done by the Bureau of Standards, the Bureau of Mines, the teaching staffs and graduates of our ceramic schools. Movements under way to develop engineers from plant operators in the pottery industries selecting for intensive education many of the fine young chaps who have generations of clay-working experience in the blood and who must otherwise remain mere mechanics is a laudable and logical procedure.

Ceramics must be thought of as one of the fields where engineering deeds are making for worth-while progress.

Helium Demonstrates Commercial Utility

IN THE demonstration of the navigability of an airship filled with helium, the C-7 of the Navy flew successfully on several short test flights around Hampton Roads and then made a trip to Washington and return as a complete answer to the feasibility of floating an airship with helium, which has approximately 92 per cent of the lifting power of hydrogen. The event will give an impetus to aviation with lighter-than-air craft and may be expected to stimulate the government's activities in the production of helium from certain of our natural gases. We believe that the Helium Board is in possession of information pointing to the existence of comparatively large percentages of helium in some natural gases not yet exploited, and with the determination of a policy as to the best method of production we may look for a renewed and more successful campaign. Incidentally it is worth recording that advocates of lighter-than-air craft foresee a large development in commercial aviation with gas-filled ships, despite the fact that this phase of the industry has apparently lagged behind airplane development.

National Income and Its Distribution

THE National Bureau of Economic Research, a non-partisan body and one apparently without material bias, numbering among its directors WALTER R. INGALLS and GEORGE E. ROBERTS, has made a study of "Income in the United States," the report being now in press. Undoubtedly many men have wished they could see a presentation of what our collective income is and who gets it. At intervals, in non-census years, the Bureau of the Census estimates the total "wealth" of the United States, and in connection with the census it ascertains the number of persons engaged in gainful occupations, although it does not attempt to ascertain how gainful the occupations are.

The presentation now available states for each of the years 1910 to 1911 inclusive: (1) The total national income, in dollars; (2) the same, per capita; (3) the total, reduced to "1913 dollars" and thus representing in substance the quantity of goods or services involved, and (4) the same, per capita.

According to the figures, the total income increased falteringly from 31.4 billion dollars in 1910 to 36.0 billions in 1915, then sharply and continuously to 65.9 billions in 1919. On account of increasing population, the per capita income of $340 in 1910 increased scarcely at all to 1915, but rose to $629 in 1919.

Reducing the dollars to the 1913 basis, and thus representing the quantity of business done rather than the money return, the curve takes a different shape. Instead of ascending continuously, it reaches a maximum in 1916 and 1917, then descends. On account of the increase in population, the per capita ascends more gradually and descends more rapidly. It was $349 for 1910, increasing to $400 in 1916 and then descending to $358 in 1919.

The presentation undertakes to show the division of income between investors and management on the one hand and those receiving wages and salaries on the other. The division shifts from 31-69 in 1910 to 26-74 in 1914, then swings the other way to 33-67 in 1916 and then reacts to 23-77 in 1918. The bureau intends eventually to furnish figures for 1919 and later years.

These figures may not be precisely accurate, but they cannot be far out. They may be said to supply a long-felt want. For instance, there has been the oft-repeated statement which many thinking men have been disposed to question, that in the last analysis labor gets 85 per cent of the money turnover. The normal seems to range between a 30 to 70 and a 25 to 75 division.

One of the interesting uses we can make of the figures presented is to make comparison between income and wealth. The Bureau of the Census reported the "wealth" of the United States at $107,104,212,000 for 1904 and at $187,739,071,000 for 1912. By interpolation we get $163,000,000,000 for 1910. The national income as reported is 19 per cent of this amount. Our wealth at the time represented the equivalent of income for a trifle more than 5 years.

The United States Chamber of Commerce reported the "wealth" of the United States in 1920 at $290,464,000,000. Interpolating between this and the census report for 1912, we get $275,000,000,000 for 1919. The income in actual dollars was 24 per cent of this, while the income reduced to 1913 dollars was 14 per cent. As the figures of wealth cannot have been swelled by the depreciation of the dollar nearly as much as the income was swelled, the ratio between quantity of product and

quantity of things representing wealth was probably about the same as in 1910, approximately 1 to 5.

A still more important use can be made of the figures. Reduced to the standard of the 1913 dollar, the per capita income was $349 in 1910 and $358 in 1919. That means, if it means anything, that in 9 years we came to work harder or more efficiently by only 2.6 per cent. We made practically no progress. With better methods, improved equipment and greater personal efficiency, we should have come in 9 years to produce a great deal more per capita. We have a great and expensive war to pay for and we have to work hard and efficiently to accomplish the task.

Haber, Nernst And the Amenities of Life

IT MADE us wince last year when the Nobel prize for 1919 was awarded to Professor HABER. Now we learn that the 1920 award goes to Professor NERNST. We comforted ourselves in regard to the Haber award with the belief that, after all, it was NERNST who was really the chief offender against his nation's solemn vow and against the faith of mankind by the introduction of the art of poisoning into warfare. As for HABER, we thought that he had merely trailed along behind NERNST. Of course after the miserable business was begun everybody had to engage in it, and no onus attaches to those who participated in it later.

But there wasn't any invention or merit in the use of poison to kill enemies. If this were an honorable thing to do, we might all be carrying wreaths to the tomb of the late LUCREZIA BORGIA. The selection of chlorine or phosgene or mustard gas or any of the other poisons was in no case a masterstroke. When the German leaders in military and physical science resolved upon it they were bound by their nation's plighted word not to do so. It was when they broke it that they offended against national honor and proved themselves to lack those inhibitions which, throughout the ages, men of good will have been trying to establish and conserve. This lack is the true criminal quality. The killing of soldiers by poison when all the world had agreed not to do it ranks along with the invasion of Belgium as a contributing cause to the present degeneration of faith.

We knew NERNST to be a leader in this crime, but we resolved for lack of certainty in regard to HABER to be lenient with him. HABER quit the service with the rank of Captain, whereas NERNST was made a Count of the German Empire by the Kaiser. Our later information is to the effect that NERNST and HABER were active rivals in this sorry business. Both men are great chemists. Both, for services rendered before their days of crime, were abundantly entitled to the great honor of the Nobel prize. We do not question the merit of these two awards on the ground of achievement in chemistry before the war. The point that we make is that their later participation in the great offense against humanity may be construed as the very reason for the awards of merit that now accrue to them from Sweden. This is not our belief. But public opinion is a curious thing, and it does not listen to explanations. It connects the names of NERNST and HABER with the preparation of the German gas attacks, and now it connects the same names with the Nobel prizes. The whole proceeding seems to us unfortunate and contrary to the intent of ALFRED NOBEL, who established the Foundation. It seems also unfair to the eminent men who received the great prize before, by putting them into such company.

Ford and Edison Inspect Muscle Shoals

MESSRS. FORD and EDISON have recently made an inspection trip to Muscle Shoals in connection with Mr. FORD'S offer for the nitrate plants and water-power development. Doubtless they found the plants in good standby condition, for they were so left by the Army officers and engineers at the time that the termination of hostilities in Europe spoiled a lot of good business in America. Likewise they must have found a good piece of work well started at the site of the Wilson Dam. So much any laymen could well undertsand in "inspecting" these overinspected properties, as the politicians who reported to Mr. FORD well knew.

Just there, however, we suspect, ends the value of an inspection trip by these gentlemen. When asked what he thought of Mr. FORD some time ago, one of our beloved statesmen replied that he was a successful manufacturer of low-priced automobiles. Likewise, all are aware of the fact that THOMAS A. EDISON is a successful organizer of scientific research. It is doubtful, however, if any conservative business concern would seriously retain either gentleman as an expert in engineering or economics relating to water-power or nitrate plants. Probably, then, this junket was a bouquet-throwing affair arranged by the politicians local to Florence and Sheffield, Ala., who may be behind the Ford offer.

Equally unbusinesslike have been all conditions surrounding the Ford offer for Muscle Shoals. After the manner of the State St. or East Side trader, a snap offer asking special privileges on the water power and a $5,000,000 bid for a plant layout costing $100,000,000, the farce of inspection is entered into with Mr. EDISON acting as Mr. FORD'S engineer. The old clothes man will give a dollar for the scarcely used dress suit, and the housewife may accept in the husband's absence. A pittance for Muscle Shoals is "good business" for Mr. FORD, but poor stewardship on the part of government officials if they accept.

It is not necessary or desirable that Muscle Shoals be sold on a single bid.

Water Power Development Shows Impetus Under New Law

IN THE first report of the Federal Power Commission we get an insight into the degree to which the country was ready for the federal water-power act of 1920. Although it had been in existence only 16 months at the time the report was made, the commission had received 270 applications covering the possible development of over 16 million horsepower. The capital expenditure required to complete these projects would exceed in the aggregate two billion dollars. But the report is not concerned alone with prospects. Construction under license is now under way on seven projects for the development of 557,800 primary and 1,276,400 installed horsepower. In addition to this, the commission has authorized twenty-seven preliminary permits and thirty-one licenses, involving 1,415,600 primary and 2,627,000 installed horsepower. These are impressive figures, particularly for the period of industrial depression through which we have passed. Under the circumstances the Federal Power Commission may be pardoned for feeling that hydro-electric power development will be the outstanding industrial fact of the next quarter of a century.

Readers' Views and Comments

Sound Ingots and Rails as a Matter of Course

To the Editor of Chemical & Metallurgical Engineering

SIR:—I have read with great interest the communication of Sir Robert Hadfield, appearing in CHEMICAL & METALLURGICAL ENGINEERING of Oct. 26, 1921, and although I am in entire accord with Sir Robert that "sound ingots will result in sounder rails," I cannot agree with him that production of sound ingots has not had a full and proper chance of being investigated and tested on a large scale in America. I also must take exception to his intimation that the American practice of producing sound steel ingots has been attempts to follow or copy his system. At the present time, though steel production is very light, there is being produced in large or so-called tonnage mills approximately 100,000 tons of sound steel ingots per month by a distinctly American method, which, I am certain, does not use any of the features patented by Sir Robert Hadfield.

Our methods for producing sound steel do, however, employ the fundamentals which are essential to the production of sound homogeneous ingots, namely:

First. That the bath of metal be thoroughly deoxidized before teeming, so that no marked chemical reaction takes place during solidification.

Second. That the metal be cast in an ingot mold whose inside dimensions are enough greater at the top to prevent internal bridging of the shrinkage cavity.

Third. That the ingot be kept in substantially a vertical position until solidification is complete.

Fourth. That a suitable refractory sink-head be used.

Sir Robert Hadfield's method, as I understand it, specified a fifth—namely, to place a solid fuel or heating material on top of the sink-head portion of the ingot and to keep this fuel at a high temperature by means of a blow-pipe or forced draft. This latter provision I do not consider fundamentally essential, as we are daily making many heats of 3- to 4-ton ingots in which the sound product in bloom or billet averages over 90 per cent of the total weight of the ingot.

My work during the past 10 years for the betterment of steel ingots may not be strictly classified as original research work, as many of the results obtained by me were previously predicted by Henry M. Howe and Bradley Stoughton in their pioneer work with wax ingots in 1906-07 and were indicated by DeLavell in a Swedish patent of 1881. Such work as I have contributed to the art and science of the production of sound steel ingots has primarily been that of carrying out in a feasible mechanical manner, with new apparatus, the methods and theories advanced in a broad manner by Messrs. Howe and Stoughton, so that sound ingots can be commercially produced without interference with production.

The rounded concavo-convex bottom of an ingot I have found absolutely essential in the prevention of cleavage planes, which are the potential cause of most butt-cracks and internal flaws in the lower portion of ingots cast on flat stools, as used, I believe, by Sir Robert Hadfield and as has usually been the practice with all large ingots in tonnage production. The metal of the bottom of such ingots, which theoretically should be the soundest, is frequently full of internal flaws.

The manifest advantages of the big-end-up mold type are now so well known and generally understood, both as to benefits obtained in the reduction of shrinkage cavity or pipe and in the reduction and lifting of axial segregation, that it is not necessary to specify them.

It may be well to state specifically the important patented features of the Gathmann ingot mold, and these are indicated as follows:

A. Heavy, heat-absorbing walls at the lower and lighter mold walls at the upper portion of the ingot.

B. Concavo-convex rounded bottom of mold integral with the body or side walls of mold, to prevent cleavage planes at the base of the ingot, and to allow stripping without danger of finning underneath the mold walls.

C. Suspended conical base closure plug whereby the ingot may be moved upward in the mold.

D. Metal plate seal for preventing sticking of ingot to the stripping plug.

The above substantially are the important features which I have worked out for mass production of big-end-up ingots such as produced in large tonnage by American practice. I have also found that the sink-head of refractory material should be as nearly the maximum diameter of the ingot as may be workable in any specific mold, and that the volume of the sink-head should be at least 10 per cent of the total volume of the fluid ingot in order to assure that segregation of a harmful nature is all contained within the sink-head after solidification of the ingot. This results in approximately 94 per cent of sound steel in body of the ingot.

It might be of interest to your readers to have Sir Robert Hadfield plainly state the important patented features of his mold and of the British practice for producing sound ingots, and I trust that a public letter from him may be forthcoming specifically pointing out the patented features covered by him which he considers essential to carry out the British method of sound steel production.

That rail steels are still generally made from the cold top pyramidal big-end-down ingot is not because the rail manufacturer is unaware that molds and methods are in daily use which could be applied to the production of rail ingots and assure of the soundness of the rails, but is, I believe, primarily caused by the undoubted increased expense of suitably and thoroughly deoxidizing the bath of metal before teeming. This deoxidation unquestionably adds materially to the cost of the production and finishing of the steel, and rail makers, with but few exceptions, prefer to use a steel which is not thoroughly deoxidized, since the latter yields a larger tonnage at less cost per ton.

The railroads are fundamentally responsible for this condition, as it is within their power to specify that the ingots from which the rails are rolled shall be *thoroughly* deoxidized as well as the present knowledge of the art may permit. Buyers of other high-grade products do thus specify, and the steel maker, be it of rails or any other product, will, I feel certain, be governed largely by the requirements of the buyer.

EMIL GATHMANN,
Vice-President and General Manager,
Gathmann Engineering Co.
Baltimore, Md.

Endurance of Steel Under Repeated Stresses

Fatigue Tests on Many Commercial and Alloy Steels Develop No Evidence of "Endurance Limit"—Ultimate Tensile Strength Closely Related to Endurance Stress at 100 Million Cycles—Special White-Souther Machine and Semi-Logarithmic Graphs Used

By D. J. McADAM, Jr.
Metallurgist, U. S. Naval Engineering Experiment Station

FOR several years the subject of endurance of steel under repeated stresses has been investigated at the U. S. Naval Engineering Experiment Station. This investigation has included a variety of carbon and alloy steels that have been heat-treated in various ways. For each type of steel, in addition to the endurance tests, tension, torsion, hardness and impact tests have been made.

Endurance Testing Machine

In the endurance tests described in this paper, the test specimen was arranged as a rotating cantilever beam. During every revolution of the specimen under test, it was subjected to definite alternate tension and compression.

The machine used for this purpose has been developed at the U. S. Naval Engineering Experiment Station. It is a modification of the White-Souther machine. As shown in Fig. 1, this machine is composed of units each capable of testing four specimens at once. Although

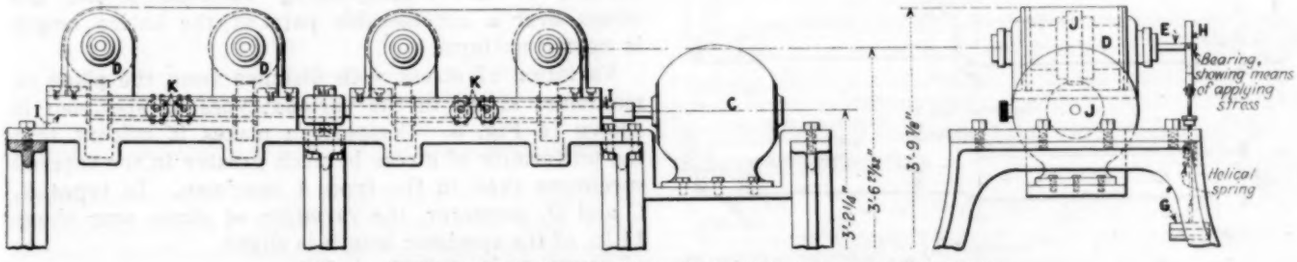

FIG. 1. GENERAL DRAWING OF ENDURANCE TESTING MACHINE

Fig. 1 shows two units on the same side of the motor *C*, the units at the Naval Experiment Station are assembled so that the motor is between two units.

Each of the rotating hollow specimen holders *D* holds two test specimens *E*. Adjustable weights *F* are suspended from the end of every test specimen by means of the rods *G* attached to the ball bearings *H*. Below and at right angles to the specimen holders is a long shaft *I* driven by the motor *C*. Specimen holders are rotated by means of spiral gears *J* on the shaft and on the outside of the hollow cylinders. By means of the clutches *K* the rotation of any specimen holder may be started or stopped while the motor shaft is rotating at full speed.

An enlarged view of one of the specimen holders is shown in Fig. 2. It will be noticed that the hollow specimen holder *D* and the sleeve *L* that surrounds the test specimen *E* are each tapered. The tapered sleeve is split, nearly to the inner end, so that it will fit both specimen and holder.

The method of inserting and withdrawing the specimen and tapered sleeve from the hollow tapered specimen holder is due to L. E. Foster, assistant foreman of the Naval Engineering Experiment Station. As shown in Fig. 3 the outer end of the tapered sleeve is threaded so that the hexagonal nut *N* can be attached; knurled nut *O* is then adjusted. By means of the interaction of these two nuts the tapered sleeve *L* holding the specimen *E* may be forced into or removed from the hollow tapered specimen holder *D*.

This method of inserting and removing the test specimen is far superior to the method used in the original White-Souther machine. The violence necessary in inserting and removing the specimen by the old method soon put the surfaces of tapered sleeve and sleeve holder in such condition that the specimen was not properly centered and consequently wabbled when revolved. By use of the improved method, however, the hardened surfaces of tapered sleeve and sleeve holder remain true indefinitely, and the centering of the specimen is so accurate that from a distance of several feet it is difficult to see whether or not the specimen is revolving.

Early in this investigation it was found that if the load is allowed to act on a test specimen while starting or stopping the machine, the specimen is usually bent so that it is of no further use. For a successful endurance test the load must act on the specimen only while it is rotating at full speed. Evidently at a speed somewhat less than the usual running speed corresponding to the

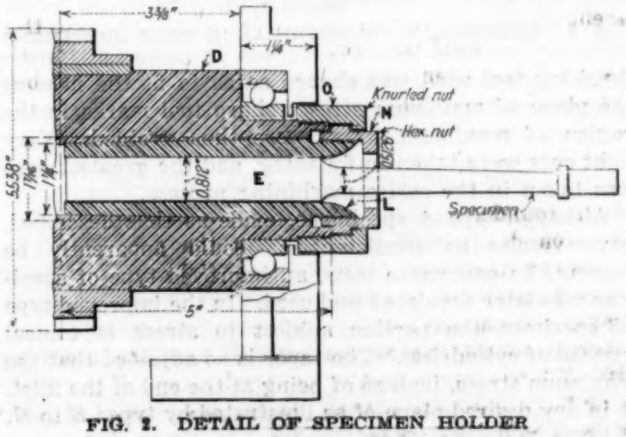

FIG. 2. DETAIL OF SPECIMEN HOLDER

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natural frequency of vibration of the weighted specimen, there is excessive vibration of the weighted specimen. The frequency of vibration varies inversely with the load applied and with the types of specimen used is evidently below the usual running speed for loads above about 50 lb. Since the loads used were usually considerably greater than 50 lb., the critical speeds in these investigations were probably always below the actual running speed. Nevertheless, to dampen any synchronous vibrations and diminish their frequency, the weights were suspended by means of helical springs in all the later experiments.

Apparatus, not shown in Fig. 1, was developed for automatically removing the load from the specimen when the speed slackens or the machine stops, consisting of a system of counter-weights, levers and magnetic release. It was developed by L. E. Foster and John Amoss of the Experiment Station.

Test Specimen

The test specimen originally used in this investigation was of type *A* shown in Fig. 3. The left end, when under test, is gripped by the tapered sleeve, and is large enough to be used for a tension or alternating torsion test after the rotating cantilever endurance test is finished. In type *A* (Fig. 3) under test, the maximum stress is at the end of the ½-in. fillet. The

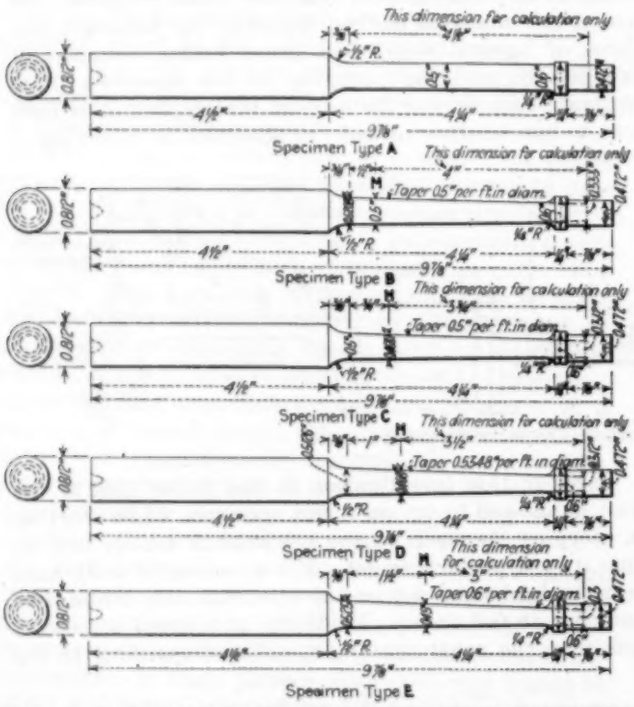
This dimension for calculation only
Specimen Type A
Taper .05" per ft. in diam.
Specimen Type B
Specimen Type C
Taper 0.5348" per ft. in diam.
Specimen Type D
This dimension for calculation only
Taper .06" per ft. in diam.
Specimen Type E

FIG. 3. DIMENSIONS OF ENDURANCE TEST SPECIMENS

finishing tool used was shaped so as to fit the fillet at the plane of maximum stress; sharp tool marks in the region of maximum stress were thus avoided. Very light cuts were taken in finishing, and the greatest care was taken in the entire machining process.

Although type *A* specimens, made as thus described, gave results as consistent as could apparently be expected in endurance tests, an improved type of specimen was later developed and used. In the improved type of specimen the portion subject to stress is conical instead of cylindrical. The taper is so adjusted that the maximum stress, instead of being at the end of the fillet, is in any desired plane *M* as illustrated by types *B* to *E*. Moreover, while in type *A* specimens the stress falls off rapidly with distance from the plane of maximum stress, in the other specimens the taper can be so adjusted that the stress is nearly uniform over a considerable length of the specimen.

The principle used in designing the tapered specimen is as follows: If a cantilever beam is made of such shape that the surface is a cubic-paraboloid, the maximum stress will be uniform throughout its entire length. Machining a test specimen to such a shape would

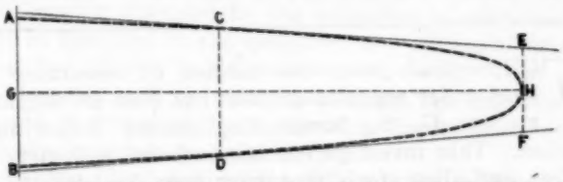

FIG. 4. DETERMINING TAPER AND LOCATION OF PLANE OF MAXIMUM STRESS

evidently be impracticable. Fortunately, however, simple tapered specimens can be so designed that their conical surfaces are tangent to a cubic-paraboloid at any desired plane, as illustrated by Fig. 4. For any such cubic-paraboloid the line *CD*, connecting any two opposite points of tangency, is one and one-half times as long as the line *EF*. In a conical specimen of longitudinal section *ABFE*, all points on the surface except those in the plane passing through *CD* are outside the cubic-paraboloid; *CD* is, therefore, the plane of maximum stress. But, since the conical surface for some distance on either side of the plane of maximum stress in these specimens does not differ greatly from the surface of the corresponding cubic-paraboloid, the stress over a considerable part of the entire length is nearly uniform.

Variation of stress with distance from the plane of maximum stress in the various types of specimen is shown in Fig. 5. Comparison makes it evident that the uniformity of stress is much greater in the tapered specimens than in the type *A* specimen. In types *B*, *C* and *D*, moreover, the variation of stress over about 1½ in. of the specimen length is slight.

Concentration of Stress at the Fillet

The stress at the end of the fillet, even after the most careful machining, is undoubtedly somewhat above the theoretical value. It seemed desirable, therefore, to adopt a type whose plane of maximum stress is so far from the fillet that the specimen will not break there. In such a specimen, the theoretical stress at the fillet would be enough below the maximum stress to offset the excess stress due to the fillet.

To determine the best type of specimen to use, and at the same time to get information in regard to the influence of the fillet in increasing the actual stress beyond the theoretical value, a series of endurance tests was made on specimens of the various types, although these comparative tests were not made until after type *A* specimen had been in use for some time. Specimens of the various types were made from round rods of mild steel heat-treated in three different ways and stressed sufficiently to cause breakage after a comparatively few revolutions.

The results may be summarized as follows: Of two type *B* specimens, both broke at the fillet. Of twelve type *C* specimens, only two broke at the fillet. Of seven type *D* specimens, only one broke at the fillet. Of four

type *E* specimens, none broke at the fillet. In types *C* to *E* the stress distribution is such as to overcome the excess stress due to the fillet. Since, as shown in Fig. 5, the stress distribution is more uniform in type *C* than in the other types, this was finally adopted for use instead of the original type *A*. Since in this specimen the stress over a length of about 1½ in. does not vary more than about 1½ per cent, it might be expected that, due to slight irregularity of material, fracture may occur anywhere within these approximate limits. It has been found that the position of fracture may vary

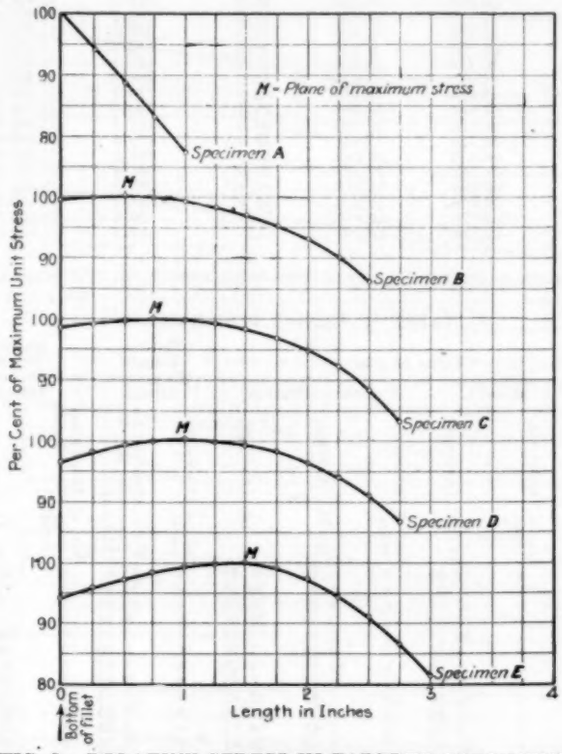

FIG. 5. RELATIVE STRESS IN TAPERED SPECIMENS

throughout several inches of the length of the specimen. Though some type *C* specimens break at the fillet, about as many specimens break at an equal distance the other side of the plane of maximum stress, so it seems probable that the fillet has practically no influence.

The comparative tests on various types of specimen have given some indication of the amount of the excess stress due to the fillet. This excess stress is evidently greater than ½ per cent, the drop in stress in type *B* specimen from the plane of maximum stress to the fillet, but less than 1½ per cent, the corresponding drop in stress in type *C* specimen. It was finally decided that a correction of 1 per cent should be added to the theoretical fiber stress values in all type *A* specimens.

MATERIAL

The Bethlehem Steel Co. co-operated in this investigation by furnishing nearly all the material, R. M. Bird of this company giving valuable aid in suggesting and making provisions for suitable material. It was furnished in the form of rolled rods about 13 ft. long and 1¼ in. to 1⅛ in. in diameter. The American Rolling Mill Co. also supplied bars of "Armco" ingot iron.

The material is described in Table I. Chemical analysis is shown in Table II. Nearly every kind of steel was heat-treated by the makers in two different ways, to give proportional limits of alloy steels at about 60,000 and 110,000 lb. per sq.in.

Some of the material furnished by the Bethlehem Steel Co. was annealed at the Naval Engineering Experiment Station. In designating this material, the letter *a* has been added to the marking.

TENSION TESTS

Average results of several tension tests on every kind of material are given in Table III. The tests were made on an Olsen 50,000-lb. machine. The test specimen was of the Navy standard type, having a 2-in. test length and a 0.505-in. test diameter. The extensometer was of Riehle type. For every experiment, a stress-strain diagram was drawn, and from this the proportional limit was obtained. Speeds below proportional limit were 0.0183 in. per minute per inch test length, and 0.117 in. beyond that point.

TORSION TESTS

Average results of individual torsion tests for every kind of material are given in Table IV. The machine used was of Riehle type, having a capacity of 60,000 lb. The specimen has a 3-in. test length and ¾-in test diameter. In calculating the stresses up to the proportional limit, the equation $T = \frac{\pi}{16} SD^3$ was used, whereas in calculating the maximum stresses the equation $T = \frac{\pi}{12} SD^3$ was used, where T represents the torque, S represents the stress and D represents the diameter of the specimen. Speed of testing below the proportional limit was 1.26 deg. per minute, and 160 deg. above that point.

HARDNESS TESTS

Average results of two Brinell and scleroscope hardness tests on each material are given in Table III. The machine used in the Brinell tests was an Olsen compound lever machine with standard 10-mm. ball, and the diameter of the impression was measured by a micrometer microscope.

CHARPY IMPACT TESTS

Results of Charpy impact tests by the Bethlehem Steel Co. and by the Naval Experiment Station are given in Table V. An American-made Charpy impact machine of 31 kg.-m. capacity was used by the Naval Experiment Station. The test specimen was a notched bar 0.394 x 0.394 x 2.165 in. The notch, 1 mm. wide, extended halfway through the cross-section of the specimen, with radius of curvature at the bottom of the notch of ½ mm. With a few exceptions, the notch was formed by drilling a hole 1 mm. in diameter at the center of the specimen and afterward cutting the notch from the side of the specimen to the hole. Some specimens from three of the alloy steels, however, were so hard that they could not be drilled; in these eight specimens the notch was cut with a V-shaped tool having a ½-mm. radius at the edge.

FREMONT AND IMPACT-SHEAR TESTS

The same table also gives results of impact tests made at the Watertown Arsenal by the Fremont method and at the Naval Experiment Station by the impact-shear method.[1] The latter was developed at the Naval Experiment Station, and uses an unnotched specimen ¼ x ⅜ in. in cross-section. By moving this specimen forward

[1] D. J. McAdam, Jr., "Endurance and Impact Tests of Metals," *Proc.*, A.S.T.M., vol. 16, Part II, (1916).

TABLE I. KEY TO MATERIAL DESIGNATIONS

Mark	Material — Kind	Heat-Treatment
A 1	0.13 Carbon steel	Annealed 1350°
A 2	0.14 Carbon steel	As rolled
B	0.21 Carbon steel	As rolled
C 1	0.30 Carbon steel	Annealed 1200°
C 2	0.31 Carbon steel	Quenched in oil 1525° and annealed at 1200°
D 1	0.48 Carbon steel	Annealed 1350°
D 2	0.49 Carbon steel	Quenched in oil 1600° and annealed 1150°
E	0.77 Carbon steel	Annealed at 1350°
F	Nickel steel	To approximate proportional limit of 60,000 lb. per sq.in.
G	High-chromium steel	To approximate proportional limit of 60,000 lb. per sq.in.
H 1	Nickel-molybdenum steel	To approximate proportional limit of 60,000 lb. per sq.in.
H 2	Nickel-molybdenum steel	To approximate proportional limit of 110,000 lb. per sq.in.
I 1	Chromium-molybdenum steel.	To approximate proportional limit of 60,000 lb. per sq.in.
I 2	Chromium-molybdenum steel.	To approximate proportional limit of 110,000 lb. per sq.in.
J 1	Chromium-vanadium steel	To approximate proportional limit of 60,000 lb. per sq.in.
J 2	Chromium-vanadium steel	To approximate proportional limit of 110,000 lb. per sq.in.
K 1	Low-nickel-chromium steel	To approximate proportional limit of 60,000 lb. per sq.in.
K 2	Low-nickel-chromium steel	To approximate proportional limit of 110,000 lb. per sq.in.
L 1	High-nickel-chromium steel	To approximate proportional limit of 60,000 lb. per sq.in.
L 2	High-nickel-chromium steel	To approximate proportional limit of 110,000 lb. per sq.in.
M 1	Si-Mn spring steel	To approximate proportional limit of 60,000 lb. per sq.in.
M 2	Si-Mn spring steel	To approximate proportional limit of 110,000 lb. per sq.in.
N 1, 2, 3	Ingot iron	As rolled
O 1	0.22 Carbon steel	As received
O 2	0.23 Carbon steel	Heated to 1600° F., held ½ hour, cooled in oil, reheated to 900° F., held ½ hour cooled in furnace
O 3	0.23 Carbon steel	Heated to 1600° F., held ½ hour, cooled in oil, reheated to 1100° F., held ½ hour, cooled in furnace
O 4	0.23 Carbon steel	Heated to 1600° F., held ½ hour, cooled in oil, reheated to 1300° F., held ½ hour, cooled in furnace

TABLE II. AVERAGE RESULTS OF CHEMICAL ANALYSES

Material	C	Mn	P	S	Si	Ni	Cr	V	Mo	As
A 1	0.13	0.56	0.008	0.047	0.17	....	.....	....	....	....
A 2	0.14	0.53	0.008	0.056	0.17	....	.....	....	....	0.010
B	0.21	0.82	0.060	0.080	0.08	0.206	0.017	....	....	....
C 1	0.29	0.52	0.010	0.051	0.17	....	.....	....	....	....
C 2	0.31	0.47	0.013	0.03	0.16	....	.....	....	....	....
D 1	0.48	0.60	0.010	0.038	0.19	....	.....	....	....	....
D 2	0.49	0.63	0.011	0.036	0.18	....	.....	....	....	....
E	0.77	0.55	0.037	0.047	0.18	....	.....	....	....	....
F	0.29	0.66	0.005	0.046	0.14	3.70	.....	....	....	....
G	0.21	0.59	0.017	0.017	0.79	0.13	13.31	....	....	....
H 1	0.41	0.45	0.037	0.020	0.20	1.72	.....	....	0.13	....
H 2	0.42	0.47	0.38	0.020	0.25	1.68	.....	....	0.12	....
I 1	0.40	0.52	0.033	0.024	0.26	....	0.95	....	0.10	....
I 2	0.42	0.53	0.032	0.023	0.25	....	1.04	....	0.09	....
J 1	0.24	0.30	0.046	0.044	0.29	0.173	1.16	0.23	....	....
J 2	0.53	0.50	0.005	0.038	0.22	....	1.46	0.23	....	....
K 1	0.43	0.63	0.012	0.038	0.22	0.47	1.10	....	....	....
K 2	0.41	0.64	0.009	0.033	0.20	1.45	1.10	....	....	....
L 1	0.33	0.47	0.007	0.052	0.18	3.18	0.96	....	....	....
L 2	0.33	0.46	0.006	0.051	0.19	3.16	0.95	....	....	....
M 1	0.55	0.65	0.024	0.037	1.97	....	.....	....	....	....
M 2	0.51	0.66	0.029	0.045	1.96	....	.....	....	....	....
N	0.023	0.037	0.002	0.031	0.005	....	.....	....	....	....
O 1	0.23	0.37	0.016	0.033	0.021	....	.....	....	....	....
O 2, 3, 4	0.23	0.41	0.012	0.033	0.044	....	.....	....	....	....

TABLE III. AVERAGE TENSION AND HARDNESS TESTS

Material	Maximum Stress Lb. per Sq.In.	Proportional Limit, Lb. per Sq.In.	Yield Point, Lb. per Sq.In.	Elongation, per Cent in 2 In.	Reduction of Area, per Cent	Brinell Hardness Number	Shore Scleroscope Number
A 1	54,520	26,250	26,250	43.5	70.5	108.9	17.3
A 2	58,220	31,250	31,250	38.8	63.5	118.5	18.7
B	70,710	39,870	40,500	35.3	62.9	142.2	21.0
C 1	69,930	35,000	36,870	34.5	50.1	143.1	21.3
C 2	71,250	37,500	40,000	34.5	67.0	147.2	21.6
D 1	81,400	38,750	38,750	31.3	53.5	156.6	22.9
D 2	101,700	53,800	56,360	25.5	52.5	195.0	27.0
E	111,120	46,250	47,500	17.3	27.3	211.0	26.3
F	92,120	60,000	61,250	29.8	54.8	183.4	23.4
G	97,500	61,250	61,250	30.5	59.8	193.7	26.6
H 1	104,720	51,250	56,250	21.3	41.0	211.0	27.0
H 2	133,350	100,000	102,500	19.8	51.3	244.8	35.4
I 1	92,250	51,250	57,500	27.0	57.5	185.0	28.3
I 2	141,370	112,500	115,000	18.5	50.5	279.2	37.9
J 1	79,550	47,500	49,170	30.7	57.2	162.7	23.1
J 2	146,570	114,000	120,500	17.5	53.4	292.0	37.7
K 1	92,900	48,330	49,170	29.8	57.3	188.3	25.3
K 2	133,690	105,620	108,750	22.3	54.6	268.8	35.3
L 1	103,000	50,000	52,500	27.0	49.5	208.0	22.0
L 2	133,370	105,000	108,750	20.7	58.2	260.4	35.7
M 1	111,750	57,500	60,000	24.5	40.3	226.2	25.5
M 2	157,450	100,000	101,000	16.5	40.0	305.6	36.6
N 1, 2, 3,	44,250	20,000	25,000	48.5	74.5	86.6	11.0
O 1	64,250	36,250	37,500	39.0	61.5	.....	....
O 2	67,500	43,000	44,250	40.0	22.2	.....	....
O 3	66,500	41,000	42,000	39.0	22.2	.....	....
O 4	60,000	36,120	37,250	40.0	22.6	.....	....

TABLE IV. TORSION TEST RESULTS

Average of all determinations

Material	Maximum Stress, Nominal, Lb. per Sq.In.	Proportional, Limit, Lb. per Sq.In.	Angle of Twist at Prop. Limit, Min. (Per Linear Inch)	Angle of Twist at Break, Deg. (Per Linear Inch)	Modulus of Rigidity, Lb. per Sq.In.
A 1	46,550	19,320	15.5	369.8	12,300,000
A 2	45,910	16,900	17.1	288.1	10,200,000
B	57,530	26,400	22.8	273.9	10,500,000
C 1	54,660	22,330	19.2	225.4	10,500,000
C 2	59,020	26,560	20.3	326.6	12,300,000
D 1	62,490	25,350	22.8	187.1	10,500,000
D 2	76,890	41,650	30.9	245.8	12,000,000
E	80,240	34,410	25.8	105.3	12,400,000
F	68,530	38,940	32.8	212.1	10,900,000
G	72,720	43,460	33.3	232.5	12,300,000
H 1	68,380	31,690	30.0	113.8	9,900,000
H 2	90,250	65,800	55.8	171.1	11,900,000
I 1	69,050	41,650	31.9	264.9	12,100,000
I 2	93,080	76,670	62.9	220.8	11,500,000
J 1	61,940	31,090	25.1	290.8	12,100,000
J 2	96,110	80,900	64.5	149.3	12,400,000
K 1	70,320	35,620	28.3	254.8	11,900,000
K 2	90,450	69,730	54.8	205.7	11,500,000
L 1	71,360	29,580	23.9	243.6	11,700,000
L 2	88,440	66,610	61.4	201.3	10,800,000
M 1	77,890	36,220	30.0	131.8	11,600,000
M 2	102,570	66,410	53.6	120.8	11,500,000
N 3	41,220	17,500	13.8	409.3	11,600 000

TABLE V. IMPACT TEST RESULTS

Material	Charpy Impact — Bethlehem Steel Co. — No. of Determinations	Charpy Impact — Bethlehem Steel Co. — Ft.-Lb. (Average)	Charpy Impact — Experiment Station — No. of Determinations	Charpy Impact — Experiment Station — Kg.-M. (Average)	Charpy Impact — Experiment Station — Ft.-Lb. (Average)	Fremont Impact Watertown Arsenal — No. of Determinations	Fremont Impact Watertown Arsenal — Work Absorbed by Specimen, Kg.-M. (Average)	Impact Shear Experiment Station — No. of Determinations (Two Specimens)	Impact Shear Experiment Station — Ft.-Lb. (Average)
A 1	4	37.00	8	5.10	36.85	4	23.9	8	36.76
A 2	4	47.02	8	6.96	50.34	4	25.0	8	35.86
B	3	31.05	6	4.23	30.59	4	20.66	8	38.68
C 1	4	18.41	16	2.90	21.01	8	9.91	8	33.12
C 2	4	20.15	8	2.18	15.77	3	8.93	8	39.41
D 1	4	6.52	8	0.52	3.76	4	6.00	8	34.28
D 2	4	7.59	8	0.59	4.28	4	7.62	8	36.27
E	4	7.34	7	0.25	1.85	4	3.87	8	28.26
F	4	36.96	8	5.20	37.65	4	21.15	8	35.60
G	5	14.46	5	2.09	15.16	4	4.85	8	37.03
H 1	4	9.36	8	1.42	10.32	4	5.38	8	28.55
H 2	4	22.41	7	3.10	22.45	4	8.78	8	30.43
I 1	4	26.90	8	3.38	24.45	6	14.73	8	39.91
I 2	4	28.92	8	4.04	29.12	4	11.08	8	27.58
J 1	3	19.66	8	3.07	22.23	3	12.73	8	40.14
J 2	..	.....	6	1.84	13.35	4	13.55	8	27.64
K 1	4	23.31	8	3.56	25.66	2	7.5	8	38.50
K 2	5	27.27	4	4.26	30.83	4	10.9	8	31.02
L 1	5	32.91	8	4.66	33.71	3	16.8	8	36.07
L 2	4	30.42	5	4.11	29.78	4	13.5	8	30.02
M 1	4	5.80	8	0.44	3.20	4	3.45	8	31.01
M 2	1	11.79	8	0.51	3.69	4	5.82	8	30.50
N 1	..	.....	3	3.31	23.94	..	.....	4	36.60

TABLE VI. RELATIONS BETWEEN OTHER PHYSICAL PROPERTIES AND ENDURANCE STRESSES AT 10^6 AND 10^8 CYCLES

Material	Endurance Stresses At 10^6 Cycles	Endurance Stresses At 10^8 Cycles	Ratio Endurance Stresses, 10^6 and 10^8 Cycles	Ratio of Endurance Stress, 10^8 Cycles to Ultimate Tensile Strength	Ratio of Endurance Stress, 10^8 Cycles to Brinell Hardness	Ratio of Endurance Stress, 10^8 Cycles to Ultimate Torsional Stress
A 1	35,000	26,000	0.74	0.48	239	0.56
A 2	35,000	24,800	0.71	0.43	209	0.54
B	43,300	33,250	0.77	0.47	234	0.58
C 1	38,400	30,000	0.78	0.43	210	0.55
C 2	37,300	30,000	0.80	0.42	204	0.51
D 1	38,500	35,000	0.91	0.43	223	0.56
D 2	46,150	41,400	0.90	0.41	212	0.54
E	46,000	39,000	0.85	0.35	185	0.49
F	49,800	46,100	0.93	0.50	251	0.67
G	52,750	47,000	0.89	0.48	243	0.65
H 1	53,000	46,600	0.88	0.44	221	0.68
H 2	67,000	57,000	0.85	0.43	233	0.63
I 1	51,200	47,000	0.92	0.51	254	0.68
I 2	72,200	67,500	0.93	0.48	242	0.73
J 1	44,000	36,100	0.82	0.45	222	0.58
J 2	74,000	66,850	0.90	0.46	229	0.70
K 1	45,800	39,150	0.85	0.42	208	0.56
K 2	69,000	54,900	0.80	0.41	204	0.61
L 1	50,000	39,900	0.80	0.39	192	0.56
L 2	70,000	60,000	0.86	0.45	230	0.68
M 1	54,500	49,100	0.90	0.44	217	0.63
M 2	71,000	62,000	0.87	0.39	203	0.60
N 1, 2, 3	28,200	23,600	0.84	0.54	250	0.57
Average			0.85	0.44	222	0.60
Average depart.			0.05	0.033	16	0.05

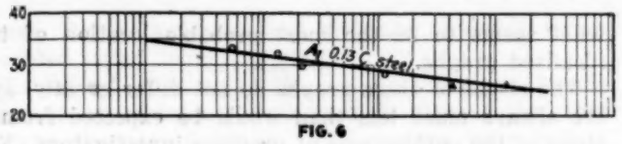

FIG. 6

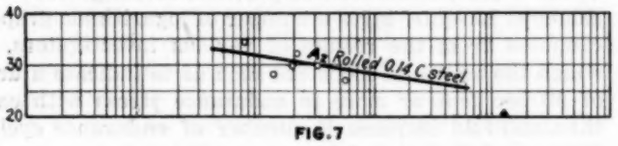

FIG. 7

FIG. 8

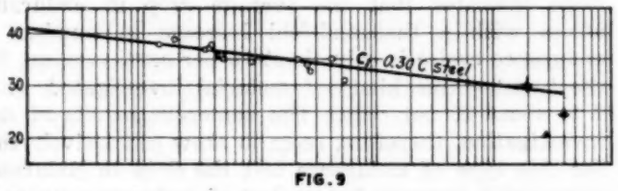

FIG. 9

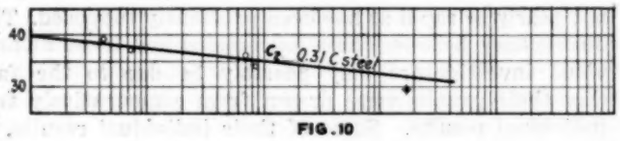

FIG. 10
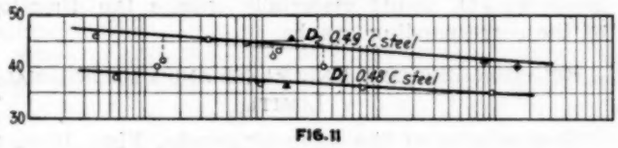
FIG. 11

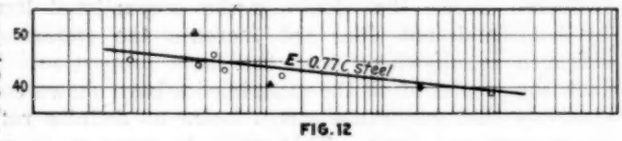

FIG. 12

FIG. 13

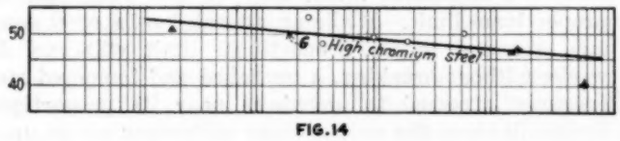

FIG. 14

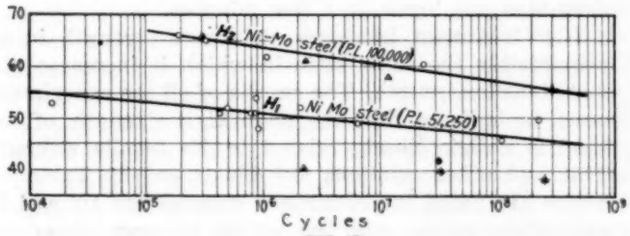

FIG. 15

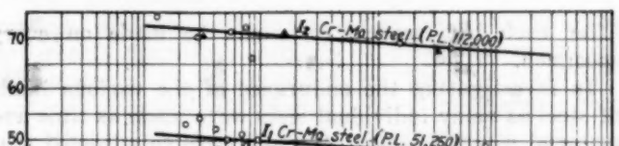

FIG. 16

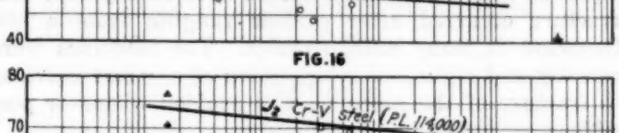

FIG. 17

FIG. 18

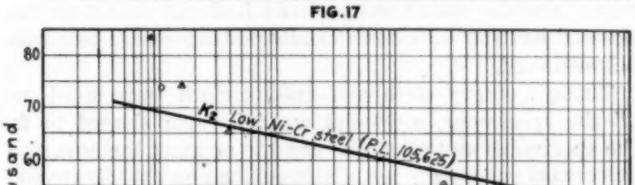

FIG. 19

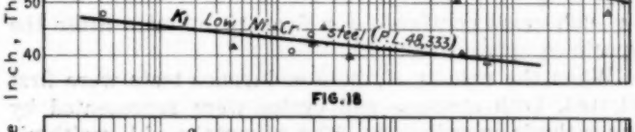

FIG. 20

FIG. 21

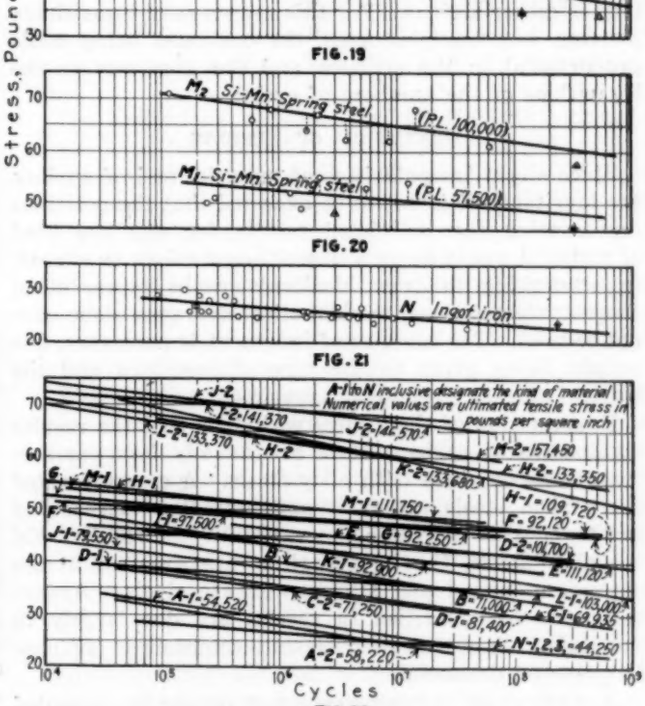

FIG. 22

FIGS. 6 TO 22. ENDURANCE OF STEELS

Fig. 6. Endurance of 0.13 plain carbon steel annealed at 1,350 deg. F.
Fig. 7. Endurance of 0.14 carbon steel as rolled.
Fig. 8. Endurance of 0.21 carbon steel as rolled.
Fig. 9. Endurance of 0.30 carbon steel annealed at 1,200 deg. F.
Fig. 10. Endurance of 0.31 carbon steel quenched and tempered.
Fig. 11. Endurance of 0.485 carbon steel quenched and tempered.
Fig. 12. Endurance of 0.77 carbon steel annealed at 1,350 deg. F.
Fig. 13. Endurance of 3½ per cent nickel steel.
Fig. 14. Endurance of high chromium (stainless) steel.
Fig. 15. Endurance of heat-treated Ni-Mo steel.
Fig. 16. Endurance of heat-treated Cr-Mo steel.
Fig. 17. Endurance of heat-treated Cr-V steel.
Fig. 18. Endurance of heat-treated low Ni-Cr steel.
Fig. 19. Endurance of heat-treated high Ni-Cr steel.
Fig. 20. Endurance of heat-treated Si-Mn spring steel.
Fig. 21. Endurance of ingot iron.
Fig. 22. Assembly of endurance tests.

after each test several tests can be made on every specimen.

In investigating the endurance of the various kinds of steel as many individual tests were made as time and material would permit. Stresses were so adjusted that fracture occurred after periods ranging from a few thousand to many million cycles. The machines were run day and night and interruption of any test previous to fracture of the specimen was avoided whenever possible.

Graphs illustrating the stress-cycle relations as developed by these tests are shown in Figs. 6 to 21 inclusive. Fig. 22 summarizes all the results shown—these curves have the ultimate strength of the material also noted. Circles represent specimens of type *C* which were broken; triangles represent broken type *A* specimens; crosses note the specimen had not failed at the time of writing or when the alternating stress test was discontinued.

Though emery cloth and crocus cloth were used on all the specimens, a special wooden form shaped to fit the specimens and fillet was used to support the abrasive on certain specimens not distinguished on the diagrams. Polishing with emery cloth No. 1 and crocus cloth was in such cases continued for 5 or 10 minutes after the specimen appeared smooth.

When the results of these endurance tests were first plotted, both stresses and cycles were represented by logarithmic co-ordinates. The advantage of logarithmic plotting is that it reduces the ordinates representing cycles to a convenient length. It has, however, the disadvantage that it minimizes stress differences, especially at the higher stresses. Since the determination of the effect of stress variations on endurance is the object of the investigation, this disadvantage of logarithmic plotting is rather serious. For this reason semi-logarithmic plotting was finally adopted, the ordinates being made proportional to the stresses and the abscissas to the logarithms of the numbers of cycles.

Discussion of Results

Since slight irregularities of material and of surface are inevitable, it is not to be expected that the positions representing the individual results for any one kind of material would lie on a line either straight or curved. In attempting to draw idealized graphs representing stress-cycle relations, mathematical averages alone cannot be used. The exercise of judgment is necessary, due weight being given to the type of specimen and the history of each individual experiment.

Examination of the figures will show that the results obtained with carbon steels are usually less variable than those obtained with alloy steels. A comparison of the carbon steels makes it apparent that increase of carbon content increases the variability of results. Of the alloy steels, the irregularities are greatest in the chromium-nickel and silicomanganese steels. Apparently the irregularities in results are due largely to inevitable slight irregularities in composition or constitution of the metal.

A study of all the endurance test results has revealed no evidence of any abrupt change in direction of stress-cycle graphs throughout the cycle range investigated. The evidence seems to indicate that the idealized graphs should be nearly straight lines. Though the lines should probably not be entirely straight, the curvature should apparently be so slight that at present it can be neglected. Straight lines, have, therefore, been drawn in what seems to be the most probable location of the idealized graphs.

The slopes of these graphs do not differ greatly, and are always much less than would be expected from a study of the publications of previous investigators. For example, Basquin[3] gives a number of logarithmic graphs, compiled from the results of various investigators, in which the angles of slope are such as to indicate a drop of 50 per cent or more in endurance stress with each thousand-fold increase in number of endurance cycles. Moore and Seeley[4] and Moore and Gehrig[4] show graphs with the same indications. Their curves were obtained from the investigations of Wöhler, from investigations at the Watertown Arsenal, and those at the University of Illinois.

On the graphs of Figs. 6 to 21, however, the average slope indicates that the average drop in endurance stress with a thousand-fold increase in number of endurance cycles is only about 15 per cent, varying, for the twenty-three kinds of material investigated, from 7 to about 29 per cent. The numerous results of this investigation, therefore, seem to show conclusively that for this type of endurance test the drop in endurance stress with increase in number of endurance cycles is not nearly so rapid as has been previously supposed. The discrepancy between these conclusions and those of previous investigators may possibly be due to the fact that their graphs were drawn from comparatively few individual results. Some of their individual results, if given weight, would materially change the directions of the corresponding graphs.

Relation Between Endurance and Proportional Limit

Comparisons of the pairs of graphs, Figs. 16 to 20 inclusive, shows that doubling the proportional limit by heat-treatment does not increase the endurance strength in anywhere near the same proportion. In fact, the results of all the experiments have shown conclusively that endurance stress bears no definite ratio to proportional limit. This ratio is greatest in annealed material. In ingot iron and annealed steels of low carbon content, the endurance stress for 100,000,000 endurance cycles is above the proportional limit; indeed, in ingot iron this endurance stress is not far from the yield point. In quenched and tempered material, however, the endurance stress may be less than half the proportional limit. While an annealed mild steel specimen stressed to its proportional limit will run for weeks without breaking, a quenched and tempered steel specimen stressed to anywhere near its proportional limit will show the entire range of temper colors up to deep blue and break in a few minutes.

Heat-treatment increases endurance strength in approximately the same ratio in which it increases ultimate tensile strength. The results of all the experiments seem to indicate that the endurance strength of any steel is rather closely related to its tensile strength. This and other relations are illustrated by Table VI, where are listed the endurance stresses for 10^6 and 10^7 endurance cycles, and the ratios between these two members for each kind of steel, a measure of the slope of the graph. The ratios of the endurance stresses for 10^7 endurance cycles to the values for ultimate tensile

[3] O. H. Basquin, "The Exponential Law of Endurance Tests," *Proc.*, A.S.T.M. (1910).
[4] H. F. Moore and F. B. Seeley, "The Failure of Materials Under Repeated Stress," *Proc.*, A.S.T.M., 1915, Part II.
[4] H. F. Moore and A. H. Gehrig, "Some Fatigue Tests of Nickel Steel and Chrome Nickel Steel," *Proc.*, A.S.T.M., 1919, Part II.

stress, Brinell hardness and ultimate torsional stress are also listed in this table.

Ratios of endurance stresses to ultimate tensile stresses are surprisingly constant, in view of the great variety of material tested. The average ratio is 0.44 and the average departure of individual values from the average is only ± 0.033. The average ratio of endurance stress to Brinell hardness is 222 ± 16. As would be expected, the constancy in this ratio is nearly as great as that of endurance to ultimate stress. The average ratio of endurance stress to ultimate torsional stress is 0.60 ± 0.057; the constancy is about the same as in the ratio of endurance stress to Brinell hardness.

According to Basquin,[5] the stress-cycle relations for endurance of metals, under two complete stress-reversals per cycle, can be expressed by the expotential equation $S = \frac{B}{N^q}$, in which S represents the endurance stress, N represents the corresponding endurance cycles, and B is a constant whose value depends on the material. Since this equation can be written also

$$\log S = \log B - q \log N$$

it can be represented on logarithmic co-ordinate paper by a straight line graph. It seems probable, however, that this straight line relationship is only approximate and that the logarithmic graph has a slight curvature with convexity downward. Extensive investigation would be necessary to decide this definitely, including a number of endurance tests extending to at least 500 million cycles.

When graph slopes are as slight as those shown in Fig. 19, a straight line logarithmic graph would remain nearly a straight line if transformed to semi-logarithmic paper. There would, however, be a slight curvature with convexity downward. Any slight downward convex curvature of a logarithmic graph would, therefore, be magnified by transforming it to semi-logarithmic paper. It seems evident, therefore, that the curvature of stress-cycle graphs can be studied best by the latter method of plotting.

Effect of Chemical Composition on Endurance Properties

A study of the figures shows that in general the graphs are located in the order of the ultimate tensile stress values. This relationship might have been predicted from a study of the constancy of the ratios given in Table VI.

In general, chemical composition seems to influence the endurance stress of a steel only as it influences its tensile stress. This rule may, however, be only approximate, since there are a few apparent exceptions shown in the figures. For example, graph M-2 of silico-manganese steel has a lower position, and graph G of high-chromium steel has a higher position in the series than would be predicted from a comparison of tensile strength values. Further experiments, however, may make it necessary to make some change in the relative position and slope of these graphs.

Comparison of the graphs showing endurance properties of annealed carbon steels and "Armco" ingot iron as received from the manufacturers shows the influence of carbon on the endurance properties of steel. As would be expected, other things being equal, the endurance stress increases with increase in carbon percentage, at least within the range investigated. The apparently anomalous position of the graph representing material B is explained by the fact that this material contains considerably more manganese than the other steels of the series. These graphs would, if assembled on one sheet, be located approximately in the order of their tensile strengths.

[5] See footnote 2.

Summary

Graphs of endurance test results on either logarithmic or semi-logarithmic paper show no evidence of abrupt change of direction throughout the cycle range investigated. Results of all the tests give cumulative evidence that the idealized stress-cycle graphs on either logarithmic or semi-logarithmic paper should be represented by nearly straight lines.

Semi-logarithmic plotting was finally adopted, since it best represents stress differences, especially at the higher stresses. Semi-logarithmic plotting, moreover, would best reveal any slight downward-convex curvature that may possibly appear as a result of further experiment. In the present state of the evidence the idealized graphs have been represented on semi-logarithmic paper as straight lines.

The angles of slope of these graphs are such as to indicate that for this type of endurance test the drop in endurance stress with increase in number of endurance cycles is not nearly so rapid as has been previously supposed. The average drop with a thousand-fold increase in endurance cycles is about 15 per cent.

The endurance stress for 100,000,000 endurance cycles bears no definite relation to the corresponding proportional limits. The ratio is higher in annealed material than in quenched and tempered material. In ingot iron and annealed mild steels of lower carbon content, the endurance stress for 100,000,000 endurance cycles is above the proportional limit. In quenched and tempered steels, it is often less than half the proportional limit.

The endurance stresses for 100,000,000 endurance cycles have been found to bear a surprisingly uniform relation to the corresponding ultimate tensile stresses. In the many kinds of material investigated, this ratio varies from about 0.35 to 0.54, the highest value being found in ingot iron. The average ratio is 0.44 ± 0.033.

The ratio of endurance stress to Brinell hardness, and the ratio of endurance stress to maximum torsional stress, are nearly as uniform as the ratio of endurance stress to ultimate tensile stress.

Until further evidence accumulates, it may be stated that chemical composition has little effect on endurance properties other than its effect on ultimate tensile stress.

A comparison of impact test results with the results of endurance tests has shown no definite relationship. Additional experiments, however, are being made, the results of which will be discussed in the future.

Acknowledgments

The writer's thanks are due to R. M. Bird of the Bethlehem Steel Co. and to the American Rolling Mill Co. for co-operation in this work. The writer wishes to acknowledge with thanks the encouragement in this work given by Captain John Halligan, Jr., U.S.N., head of the Naval Engineering Experiment Station, also the assistance received from Messrs. Foster, Vandermast, Amoss and others employed at the Naval Engineering Experiment Station.

The Volume of Air Required in Air Drying

Problems Which Confront the Average Engineer in Attempting to Find the Volume of Air Required in Air Drying—Calculation From Wet Bulb Temperatures and Psychrometric Tables—Charts for 100, 85, and 70 per Cent Ultimate Humidity

BY C. T. MITCHELL
Mechanical Division, The J. G. White Engineering Corporation

IN AIR-DRYING operations it is convenient and often essential to know what quantity of air, under certain conditions of temperature and humidity, is necessary in order to evaporate a given amount of moisture. This problem is a comparatively simple one to a specialist in air conditioning, but, on account of the many variables involved, is apt to be a perplexing one to the average engineer, who has not the time to devote to its solution in detail. Not finding tables or formulas at hand with the required information, he resorts to approximation. If he has a well-developed sense of proportion, he may make some very good guesses. On the other hand he may not. The writer has never seen any tables or charts published giving the above-mentioned information directly, and has consequently thought it worth while to prepare the accompanying charts, in the hope that some one may find them worthy of insertion in his scrap book.

Factors Affecting Atmospheric Evaporation

It is perhaps not generally realized, at least by those with a non-technical education, that atmospheric evaporation, such as goes on around us every day, consists of two distinct operations. First, there must be heat by which to vaporize the water. Next there must be an abundance of air present to associate with the vapor and carry it away. The drier the air the more water vapor it will be able to carry and the quicker will be the evaporation.

The humidity of the air in drying operations under atmospheric conditions is consequently quite as important as the temperature. It is easy to imagine that when air is highly saturated an enormous quantity of it will be required to absorb a small amount of moisture. This fact seems almost too simple to bear repetition, and yet the writer has seen the doors of dry rooms closed in order "to keep the heat in," when there was no means of circulation except through the door itself.

Since the pressure is constant in most air-drying operations, the present article deals with only two variable factors, temperature and humidity, the air being taken at constant pressure, and approximately 30 in. barometer. Most drying is done under these conditions, and a vast proportion of it, fortunately, is possible without technical guidance and with a fair amount of efficiency. Yet the average laundress would no doubt be astonished to hear that several thousand pounds of atmosphere must come in contact with the clothes hanging on her lines before they are dry. We venture to say also that many engaged in drying material of a much more refractory nature than clothes would be more or less astonished were they able to visualize the enormous quantities of air which must pass through their dry rooms, unassisted save by natural circulation. Some of them might even be inclined to doubt the figures as given in the charts. For their benefit an explanation will be given as to how the curves were plotted.

Cooling of Air During Evaporation

The problem is as follows: A certain volume of air, say a cubic foot, is brought into contact with moist material and permitted to remain there until saturated. If we know the weight of moisture in the unit of air before evaporation and subtract it from the weight of moisture in the air after evaporation, then divide the result into the number of pounds of moisture to be evaporated, it is evident that we will arrive at the number of cubic feet of air necessary, at the initial temperature and humidity. The problem is complicated, however, by the fact that the temperature of the air drops during evaporation and that each degree drop lowers the saturation point. What temperature will it finally arrive at? Also, when the air cools, it shrinks slightly in volume, but this is offset again to a certain extent by an increase in the volume due to the addition of the vapor to the original. Since we know that the latent heat of evaporation of the moisture to be removed has been borrowed from the cubic foot of air itself, we might balance these two heat quantities and arrive at the result in this way. Since the latent heat varies with the temperature and there are several other variables in the problem, with no possibility of establishing sufficient equations for a solution, we find that it would be necessary to work out the result by trial. As this would be very cumbersome and open to inaccuracies and arguments as to the correctness of the values used for the specific heat of moist air, we search for another method of solution, and find one ready made for us—namely, the tabulations of the wet and dry bulb thermometer readings as embodied in Carrier's psychrometric chart. The wet bulb temperature has been defined as the temperature to which the evaporation of water from a wet cloth cools the mercury bulb of a thermometer when slung through the air. The following definition seems more expressive if less noncommittal, however: The wet bulb temperature is the approximate ultimate temperature to which air may be cooled by the process of evaporation. This brings out the distinction between the wet bulb temperature and the dew point. The dew point is the temperature at which air reaches the saturation point when cooled by external means. The two are different and the explanation may be illustrated as follows.

Distinction Between Wet Bulb Temperature and Dew Point

Imagine two sealed boxes, each box containing 1 cu.ft. of air, the temperature and humidity of the air in both boxes to be the same. The sides of the boxes

must be perfectly insulated against heat interchange with the outside air, and each box must be capable of expanding or contracting with change of temperature, so as to keep the barometric pressure constant inside the box. In one box is a brine coil through which brine of a gradually lowering temperature is circulated. The air in the box is thus slowly cooled to the point where moisture begins to deposit on the coil. The circulation of brine is now continued at constant temperature until all the air in the box is at the same temperature as the brine. This temperature is the dew point of the original air. Into the other box we inject a tiny spray of water, and by means of a small pump located inside the box itself, we continue the spray effect, using the same water over and over again until the air has become saturated and will absorb no more. To avoid criticism we will assume that the temperature of the water at the beginning of the experiment is the same as the wet bulb temperature of the air. The temperature of the air in this box is now found to correspond to the wet bulb temperature of the air before injection of water. It is evident that the temperature in the box with the brine coil will be the lower of the two, because the brine has been continually removing heat, while no heat has been added or taken away from the other box. This may be also proved in another way: The atmosphere in the box with the brine coil has neither lost nor acquired moisture, while in the other box a definite amount of moisture has been absorbed. Since the

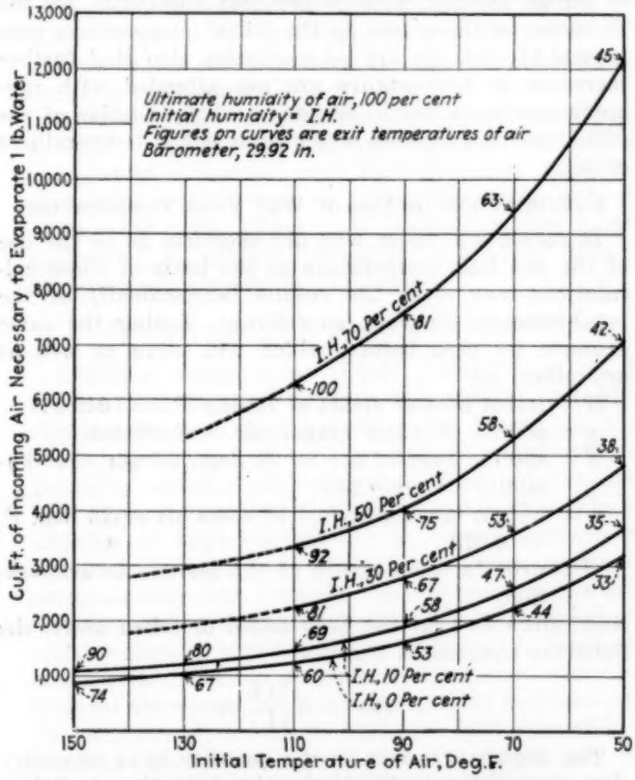
Ultimate humidity of air, 100 per cent
Initial humidity = I.H.
Figures on curves are exit temperatures of air
Barometer, 29.92 in.
I.H., 70 Per cent
I.H., 50 Per cent
I.H., 30 Per cent
I.H., 10 Per cent
I.H., 0 Per cent
Cu. Ft. of Incoming Air Necessary to Evaporate 1 lb. Water
Initial Temperature of Air, Deg. F.

FIG. 1. VOLUME OF AIR REQUIRED IN AIR DRYING, ULTIMATE HUMIDITY OF AIR, 100 PER CENT

atmosphere in both boxes is in a saturated condition at the conclusion of the experiment, we know that the atmosphere containing the most moisture must be at the higher temperature, other things being equal.

Experiments of this kind would be difficult to carry out in practice, except in a laboratory. The wet bulb, or sling psychrometer, is a simple instrument, however, and gives readings which approximate very closely to the temperature in the box with the water spray. By

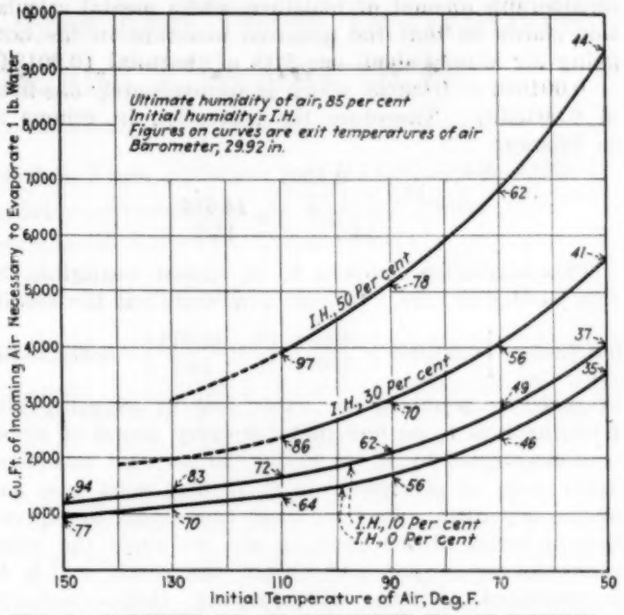
Ultimate humidity of air, 85 per cent
Initial humidity = I.H.
Figures on curves are exit temperatures of air
Barometer, 29.92 in.
I.H., 50 Per cent
I.H., 30 Per cent
I.H., 10 Per cent
I.H., 0 Per cent
Cu. Ft. of Incoming Air Necessary to Evaporate 1 lb. Water
Initial Temperature of Air, Deg. F.

FIG. 2. VOLUMES OF AIR REQUIRED IN AIR DRYING, ULTIMATE HUMIDITY OF AIR, 85 PER CENT

passing the wet, muslin-covered bulb rapidly through the air, the utmost cooling possible by evaporation is accomplished, which means that the atmosphere adjacent to the bulb is in a saturated condition.

Calculation of Volume of Air Required

To return now to the problem: A unit volume of air (surrounded by other air subject to the same conditions and therefore not affected by heat interchange) comes in contact with moisture in a drying room, absorbs all it can hold, in the case of 100 per cent evaporation, and passes out. Its exit temperature is evidently the wet bulb temperature and may be read at a glance from the psychrometer chart or from tables, provided the original temperature and humidity of the air are known. Suppose, for instance, that the initial temperature of the air is 90 deg. F. and that it carries 50 per cent humidity. The wet bulb temperature is 75 deg. Consequently the air will pass out of the dry room, if saturated, at 75 deg. A cubic foot of air in this condition holds 0.001346 lb. of water. Before entering the dry room a cubic foot of the same air contained 0.001066 lb. of water. We cannot subtract one directly from the other in order to find the net moisture acquired, because the volume has changed. We must therefore start with more than a cubic foot, so that when we reduce the temperature to 75 deg. (without adding moisture) we shall have exactly a cubic foot. This is very easily done by means of the ratio of absolute temperature; since no condensation occurs in the process of cooling, the initial moisture in the air is in a superheated condition and follows the same law of expansion and contraction as the air itself. We have another slight correction to make, since the outgoing air has taken on moisture and therefore added to its volume. Looking up the vapor pressure of saturated steam at 75 deg. F. we find it to be 0.4288 lb. absolute. Now the total pressure of the air and steam combined is 14.7 lb., since we have assumed this condition at the start. The difference is

$$14.7 - 0.4288 = 14.2712$$

If the air had been dry at the start, the correction in volume would be $\frac{14.27}{14.7}$. But it already contains a

considerable amount of moisture, and a mental calculation shows us that the acquired moisture in the outgoing air is only about one-fifth of the total (0.001346 — 0.001066 = 0.00028, which is approximately one-fifth of 0.001346). Therefore the correction in volume is as follows:

$$14.7 - \frac{0.4288}{5} = \frac{14.614}{14.7}$$

This correction happens to be almost negligible, in this particular case. We can now write out the result,

$$0.001346 - \left[0.001066 \times \frac{460 + 90}{460 + 75} \times \frac{14.614}{14.7}\right] = 0.000258 \text{ lb.}$$

of moisture acquired per cubic foot of outgoing air. Dividing into 1, we find that for every pound of moisture evaporated by air at 90 deg. 50 per cent humidity, 3,876 cu.ft. of saturated air at 75 deg. must pass out of the dry room. As it is more convenient to express this in terms of the entering air, we apply the same correction as above, and obtain the result which is incorporated in the accompanying charts—namely, about 4,000 cu.ft.

Preparation of the Curves

The curves in Figs. 1, 2 and 3 were all plotted in this manner. Calculations were all made and checked on the slide rule, as greater accuracy than this would seem to be superfluous. In fact, an accuracy of 90 per cent (assuming 100 per cent accuracy for the wet bulb records themselves) is probably all that could possibly be desired by anybody, since these curves are in no sense a contribution to scientific knowledge, but merely an aid to the engineer or plant manager in working out problems. The inevitable irregularities in the curves were smoothed out in tracing, but in no case to affect the accuracy of the reading more than 10 per cent. There are certain conditions of initial high temperature and high humidity where a slight error in the temperature reading would make a very large error in the quantity of air. In these cases the curve was either omitted, or, where the result was reasonably certain, drawn with dotted lines. Exit temperatures of the air have been shown in small figures, at regular intervals along the curves. These temperatures could be expressed by a series of curves running counter to the others, but it was felt that this would unnecessarily crowd the diagram. Three conditions of ultimate humidity, 100, 85 and 70 per cent, have been considered in Figs. 1, 2 and 3 respectively. The calculations are the same for all three, since the exit temperature of air at a given humidity may be read from the psychrometric diagram just as readily as the wet bulb temperatures.

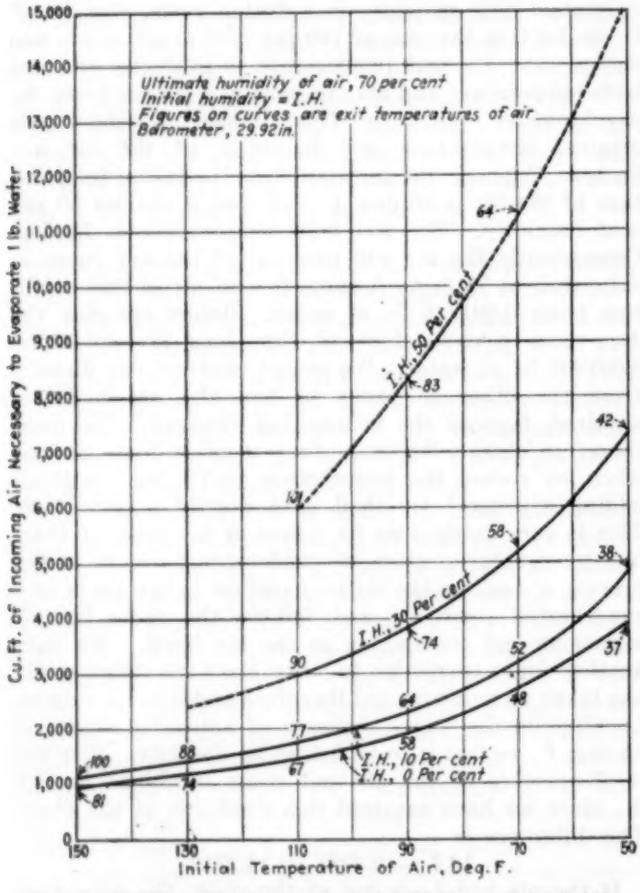

FIG. 3. VOLUMES OF AIR REQUIRED IN AIR DRYING, ULTIMATE HUMIDITY OF AIR, 70 PER CENT

Deductions From Curves

It is thought the curves will be interesting to many who are not immediately concerned with their practical value. The most outstanding thing which they illustrate is the importance of low initial humidity for efficiency in drying. For instance, it is seen that a given volume of air at 50 deg. with 10 per cent humidity will absorb as much moisture as the same volume of air at 100 deg. with 50 per cent humidity. By the flattening of the curves, as the initial temperatures pass beyond 110 deg., we are led to assume, also, that further increases in temperature are not attended with proportionate increases in efficiency, wholly outside of the difficulties and expense which high initial temperatures entail.

Confirmation of Use of Wet Bulb Temperature

In conclusion, those who are skeptical as to the use of the wet bulb temperature as the basis of these calculations may check the results independently of the psychrometric diagram, as follows: Taking the same example we used before, which will serve as well as any other, let

H = latent heat of steam at 75 deg. F. = 1049.46.
p = pounds of water evaporated = 0.000258.
S = specific heat of air at 90 deg., 50 per cent humidity = say 0.245.
w = weight of a cubic foot of same air at 75 deg. F. = 0.073.
t = drop in temperature of the air due to evaporation.

Now, since no heat has been added or taken away, the following equation is true:

$$Hp = S\frac{14.6}{14.7}wt$$

The slight correction to the quantity w is necessary since we are borrowing heat units from the air before it has taken on its quota of moisture and become an exact cubic foot.

Substituting the values and solving for t, we obtain

$$t = \frac{1049.46 \times 0.000258}{0.245 \times \frac{14.6}{14.7} \times 0.073} = 15.2 \text{ deg.}$$

which checks as closely as could be expected with the 15 deg. drop registered by the wet bulb.

New York City.

Importance of the Olefine Gases and Their Derivatives V—Ethylene Chlorhydrin and Ethylene Oxide*

Problems in the Manufacture of Ethylene Chlorhydrin From Ethylene and Hypochlorous Acid—Properties—Examples of Chemical Reactivity—Production and Characteristics of Ethylene Oxide—Other Derivatives of Ethylene Chlorhydrin

BY G. O. CURME, JR., AND C. O. YOUNG

THE two chemical derivatives of ethylene which have shown the greatest promise of winning the recognition of the industrial chemist within recent years are those which form the subject of this paper—namely, ethylene chlorhydrin and ethylene oxide. The latter being related to the former as a direct derivative formed by a simple process, they are very similar indeed in their chemical reactivity and constitute together a supplementing pair of reagents, which are characterized by their intensity of reaction and the valuable nature of the products which they may yield. To a student of the development of our organic chemical industry the position of these reagents today seems very similar to that of formaldehyde in the year 1893. At that time formaldehyde was first announced to the industrialists as available in commercial quantities, after having been known to laboratory investigators for many years. The history of its rapid increase in value to the industry needs no recounting.

Today ethylene chlorhydrin, having passed through a difficult period of factory experimentation, has emerged in a position such that it is now capable of production on any desired commercial scale, and at a commercial price. That it is destined to find a large application in synthetic chemistry is assured from the achievements already to its credit.

PREPARATION OF ETHYLENE CHLORHYDRIN

Ethylene chlorhydrin, ($ClCH_2.CH_2OH$), which has also been known as β-chlor-ethyl alcohol and glycol chlorhydrin, was first described by Wurtz[1] in 1859. Wurtz prepared it from the already known ethylene glycol by addition of hydrochloric acid. A few years later Carius[2] described the more direct synthesis by the addition of hypochlorous acid to ethylene, which was the basic reaction on which the present commercial processes have been founded. Carius prepared the hypochlorous acid by the action of mercuric oxide on chlorine, which naturally would not lend itself well to large-scale commercial operation on grounds of expense. Since this original discovery that hypochlorous acid in dilute aqueous solution does add to ethylene with formation of ethylene chlorhydrin, a great deal of work has been done on other methods of generating hypochlorous acid so that it might suitably be added to the gaseous ethylene. Lauch,[3] Bamberger,[4] Schweitzer[5] and others worked upon the idea of adding a weak acid to a solution of liquid bleach ($NaOCl + NaCl$) with the idea of liberating the free hypochlorous acid in the presence of ethylene but not the stronger hydrochloric acid. Among the acids used were boric acid, carbonic acid and sodium bicarbonate. These procedures were an improvement in the arts and to the writers' knowledge can be used to give consistent yields of ethylene chlorhydrin, although expensive in operation. A patent on the process of adding an excess of sodium bicarbonate to an alkaline solution of sodium hypochlorite in the presence of ethylene was granted to Walker[6] in 1910. McElroy[7] has taken out a series of patents on the production of ethylene chlorhydrin by the action of chlorine on ethylene and oil gas in the presence of steam, and in an electrolytic cell, although with results that do not seem as successful as those obtained by earlier processes. According to Norris[8] the Badische Anilin und Soda Fabrik has used a process which consisted in bubbling a mixture of ethylene and carbon dioxide through a suspension of bleaching powder contained in a lead vessel. It was by this process that the chlorhydrin used for mustard gas production by the Germans during the great war was largely obtained. Gomberg[9] found that concentrations of 5 to 8 per cent of ethylene chlorhydrin could be obtained by passing ethylene and chlorine into cooled water, but stated that above that concentration largely ethlyene dichloride was formed by further reaction, owing to the action of the accumulated hydrochloric acid in solution. Brooks,[10] in a recent critical survey of the manufacture of chlorhydrins, describes a similar process of his own, wherein the liberated hydrochloric acid is taken up by added salts of weak acids, such as borax or sodium bicarbonate. In this case also the ethylene dichloride reaction seems to intervene after a concentration of 5 to 6 per cent of ethylene chlorhydrin has been built up. In a process developed by the writers, which has been made the subject of a pending patent application, it has been found possible by use of a recirculation system to build up a concentration of 10 to 12 per cent of ethylene chlorhydrin with no appreciable ethylene dichloride formation, at the same time avoiding the necessity of contaminating the system with foreign salts or gaseous materials. Ethylene chlorhydrin has been in limited commercial

A contribution from the Mellon Institute of Industrial Research of the University of Pittsburgh.

*This article, the last of a series of five, treats of the technical significance of two related ethylene derivatives which are just commencing to be recognized by industrial chemists for their valuable chemical reactivity and which are now available commercially through the development work carried out by the Carbide & Carbon Chemicals Corporation. Parts I, II, III and IV were published Nov. 16, p. 907, Nov. 23, p. 957, Nov. 30, p. 999, and Dec. 7, p. 1049, respectively.

[1]Wurtz, *Ann.*, vol. 110 p. 125 (1859).

[2]Carius, *Ann.*, vol. 126, p. 197 (1863).

[3]Lauch, *Ber.*, vol. 18, pp 2, 287 (1885).

[4]Bamberger, *Ann.*, vol. 288, p. 81 (1895).

[5]Schweitzer, *Ber.*, vol. 40, p. 94 (1907).

[6]Walker, U. S. Pats. 972,952 (1910) and 972,954 (1910).

[7]McElroy, U. S. Pats. 1,253,615, 1,253,616, 1,253,617, 1,264,535, 1,295,339, 1,315,229.

[8]Norris, *J. Ind. Eng. Chem.*, vol. 11, p. 817 (1919).

[9]Gomberg, *J. Am. Chem. Soc.* vol. 41, p. 1414 (1919).

[10]Brooks, CHEM. & MET. ENG., vol. 20, p. 629 (1920).

use in Germany for some time and recently has been advertised for sale in this country as well as in France.

The pure material produced by any of the above processes is a colorless liquid of faint ethereal odor. It has a boiling point of 128 deg. C. at 740 mm. and a density of $D^{\frac{15}{4}} = 1.2130$. It is miscible with water in all proportions. As is characteristic of the alcohols, ethylene chlorhydrin also forms a constant boiling mixture. This mixture has been found to contain 42.3 per cent chlorhydrin and 57.7 per cent water by weight and boils at 96.0 deg. C. at 740 mm. It has the density $D^{\frac{15}{4}} = 1.0970$. By suitable rectification this constant boiling mixture can be separated from the more dilute aqueous solutions in which it is first produced and as such can best be brought upon the market. The process of concentration to the absolute or 100 per cent chlorhydrin is not exceptionally difficult, but adds materially to the cost of the product, as is the case with the alcohols.

The anhydrous ethylene chlorhydrin is a remarkable solvent in that it possesses the valuable solvent characteristics of both the alcohols and the organic chlorides. For this reason it is miscible with water as well as most organic liquids, and dissolves materials of all classes from inorganic salts to the cellulose esters. Patents on its use as a solvent for cellulose acetate have been taken out.[11] It has the disadvantage, however, that it is readily hydrolyzed, which limits its use as a solvent.

Chemical Reactivity

The chief value of the ethylene chlorhydrin, as stated above, is its great chemical reactivity. Possessing as it does a two-membered carbon chain with a reactive, but different, radical on each of the two ends, it offers a bivalent ethylene radical which can be used for an unlimited number of syntheses. To renew the analogy with formaldehyde, its great advantage in synthetic work is that it offers a bivalent radical, namely, methylene ($—CH_2—$) which can join with two different groups and bind together like or unlike radicals into a highly complex molecule. With ethylene chlorhydrin the same is the case, except that the uniting bivalent radical in this case is different, namely, ethylene ($—CH_2.CH_2—$) and therefore the series of derivatives will be of a different but no less valuable class.

One particular case where the value of ethylene chlorhydrin has been commercially developed is in the synthesis of indigo, as described in the patent of the Badische Anilin und Soda Fabrik.[12] In this case the chlorhydrin unites directly with aniline to give hydroxyethyl aniline, and this material in turn is condensed by a simple caustic fusion to a material that may readily be oxidized to indigo. This process is reported to be in extensive use in Germany and in Switzerland today, and is stated to have material advantages over the other syntheses. It was the chlorhydrin originally intended for this synthesis that was used to produce the first mustard gas. The same mustard gas (β,β'-dichlorethyl sulphide) synthesis is again characteristic of the bivalent reactivity of ethylene chlorhydrin.[13] Here ethylene chlorhydrin is treated with sodium sulphide, giving thiodiglycol as a first product of reaction. This substance then forms mustard gas directly by addition of strong hydrochloric acid solution.[14] Again, phenyl ethyl alcohol is produced from brombenzene and ethylene chlorhydrin by the Grignard reaction,[15] and novocain[16] through the reaction of ethylene chlorhydrin and amino benzoic esters. These examples serve only as an indication of the variety and scope of reactions in which a bivalent radical, capable of selective addition on either end, can accomplish simplified and elegant reactions in the field of commercial organic synthesis.

Production of Ethylene Oxide

From ethylene chlorhydrin solutions by action of strong caustic alkali, a rather unusual reaction occurs in which hydrochloric acid is split off from the chlorhydrin and ethylene oxide is formed directly. This reaction was first described by Wurtz[17] in 1859. In many repetitions of this process by successive investigators no essential improvements have been worked out.

The ethylene oxide $(CH_2)_2O$ prepared in this manner is a colorless liquid with a characteristic pungent odor, similar to that of pure ethylene. It is quite volatile, boiling at 12.5 deg. C. at 746 mm. It has the density $D^{\frac{0}{4}} = 0.8966$. It is miscible with water in all proportions. On account of its low boiling point, this material must be handled as a gas in any commercial work, but when liquefied in steel cylinders it is easily transported and very easily applied in any reaction.

Forming as it does a three-membered ring, ethylene oxide is characterized by its great chemical reactivity and undergoes practically the same reactions as does the chlorhydrin. In some cases it reacts even more easily. Since it can very readily be prepared in the anhydrous condition and also contains no chlorine, it is preferable in many reactions on this account. The two reagents supplement each other handsomely.

Other Derivatives of Ethylene Chlorhydrin

Other direct derivatives of ethylene chlorhydrin also appear to have commercial value. Of these ethylene glycol ($CH_2OH.CH_2OH$) has already attracted considerable interest, being produced readily by the action of sodium bicarbonate on chlorhydrin solutions.[18] This material has already been used in many applications where it has been shown that it can replace glycerine to good advantage, as in manufacture of explosives,[19] in moistening tobacco, in cosmetics, extracts and in other such uses.

Glycol monacetate ($CH_2OH.CH_2OCOCH_3$) is another direct derivative, and has attracted some attention as a solvent. In particular it is claimed to aid in dyeing artificial silk from cellulose acetate.[20] Glycol diacetate $(CH_2OCOCH_3)_2$ is another derivative, and as a high boiling solvent (b.p. 186 deg. C.) deserves some attention.

This list of higher syntheses involving chlorhydrin and its derivatives as well as that of its direct derivatives might well be continued to much greater length, but such a detailed review is beyond the scope of this paper. It is hoped, however, that it has been possible in the relatively few instances cited to show that, along with the other technical products of the olefine gases, ethylene chlorhydrin offers a new field of development to the organic chemical industry.

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[11] Ger. Pat. 288,267 (1914). U. S. Pat. 1,026,614 (1912).

[12] U. S. Pat. 778,772 (1904).

[13] V. Meyer, *Ber.*, vol. 19, p. 3260 (1896). H. T. Clarke, *J. Chem. Soc.*, vol. 101, p. 1583 (1912).

[14] This synthesis was not adopted by the Allied Powers to produce the mustard gas for the past war, as no commercial chlorhydrin process was at that time satisfactorily developed. As an operating process it is, however, the safest and yields the highest grade of material.

[15] Grignard, *Ann. Chim. Phys.* (8), vol. 10, p. 23 (1907).

[16] *J. Soc. Chem. Ind.*, vol. 39, p. 43 (1920).

[17] Wurtz, *Ann.*, vol. 110, p. 126 (1859).

[18] French Pat. 458,733 (1913).

[19] Barab, U. S. Pats. 1,307,033 and 1,307,034 (1919).

[20] Ger. Pat. 228,867 (1907).

The Electrolytic Oxidation of HCl to Perchloric Acid*

Earlier Methods for the Preparation of Perchloric Acid—Apparatus and Procedure for Studying Electrolytic Oxidation of Hydrochloric Acid—Experimental Data—Type of Cell Developed From Results of Preliminary Work—Bibliography

BY H. M. GOODWIN† AND E. C. WALKER, 3D‡

THE purpose of the following investigation was to determine the best conditions under which hydrochloric acid could be electrolytically oxidized to perchloric acid, and to devise a cell for carrying out the process on a practical scale. That perchloric acid can be formed by the electrolysis of hydrochloric acid has long been known, the fact having been noted by Count Stadion[1] in 1816. In 1898 Haber[2] investigated the electrolysis of hydrochloric acid solutions and stated that when dilute solutions are electrolyzed, small amounts of perchloric acid are formed.

Up to the time this investigation was undertaken, in 1916, perchloric acid was made by one of the following methods:

1. By heating a concentrated solution of chloric acid. As pure chloric acid is not readily prepared and the yield of perchloric acid is low, this method is of little practical value.[3]

2. By the action of fluosilicic acid on potassium perchlorate and subsequent distillation of the filtrate of dilute perchloric acid. This method is obviously difficult and of theoretical interest only.[4]

3. By the action of sulphuric acid on barium perchlorate with subsequent concentration and distillation. The chief objection is that the barium salt is expensive.[5]

4. By steam distillation under reduced pressure of a mixture of potassium perchlorate and sulphuric acid. A good yield is claimed by this method.[6]

5. By the action of concentrated hydrochloric acid on sodium perchlorate and concentration of the filtrate until excess of hydrochloric acid is driven off.[7] Mathers[8] states that this method yields 95 per cent of the theoretical acid, and with cheap sodium perchlorate would seem to be the best method thus far proposed.

6. By the action of aqua regia on ammonium perchlorate. This method is stated by Willard[9] to give good results, but owing to the explosive nature of ammonium perchlorate is restricted in its use.

All of these methods, except the first, presuppose the formation of perchlorates and the subsequent liberation of the free acid. In the following experiments the attempt was made to form the acid directly from hydrochloric acid without the intermediate formation of one of its salts.

In oxidizing the chlorine ion to the perchlorate ion it must of course pass through the chlorous and chloric stages. The theory of the formation of the chloric ion and chlorates and the best conditions for effecting this electrolytically are well known. The mechanism of the further electrolytic oxidation of the chlorate to the perchlorate ion was studied by Oechsli[10] in 1903 and more recently in a comprehensive article by Bennett and Mack[11] in 1916. The former holds that the perchlorate ion is formed only under conditions of sufficiently high overvoltage to permit the preferential discharge of chlorate ions, which then by secondary reactions with the water form chloric and perchloric acid. Bennett and Mack on the other hand maintain that experimental evidence bears out the view that perchlorate formation is due to the direct oxidation of the chlorate ion by nascent oxygen present in a state of high concentration in an anode at which there exists a high oxygen overvoltage. For a detailed discussion of these two theories Bennett and Mack's paper should be consulted.

Whatever the mechanism of the process may be, the facts seem well established that chlorate ions are most readily oxidized to perchlorate ions in acid solution, at low temperature, high current density and at electrodes, like smooth platinum, which give a high oxygen overvoltage. Chlorate ions, on the other hand, are more efficiently formed at higher temperatures, lower current densities and in concentrated solutions.

APPARATUS AND PROCEDURE

To ascertain the extent to which hydrochloric acid can be oxidized to perchloric acid under varying conditions, a large number of experiments were first carried out in the apparatus described below. This consisted of two concentric cylinders—the inner, a platinum tube 22 cm. long and 0.55 cm. diameter, which served as anode, and the outer of copper 20 cm. long and 6 cm. diameter, which served as cathode. The platinum tube passed through the center of a rubber stopper large enough to close the lower end of the copper cylinder. The stopper and upper parts of the copper tube not in contact with electrolyte were covered with paraffine to prevent corrosion by the action of free chlorine.

The temperature of the cell was regulated by passing a current of water through the anode and up and around the outer copper cylinder, the whole cell being placed in a beaker.

In series with the cell were an ammeter, a rheostat

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[1]Stadion, Gilberto, *Ann.*, vol. 52, pp. 197 and 339. See also *Liebig's Ann.*, vol. 56, p. 281; *Ann. chim. phys.* (2), vol. 7, p. 298.

[2]Haber, *Z. anorg. chem.*, 1898, vol. 16, p. 225.

[3]Millon, *Ann. chim. phys.* (3), vol. 7, p. 310; Penny, *Liebig's Ann.*, vol. 37, p. 203.

[4]Carpari, *Z. angew. chem.*, 1893, vol. 6, p. 68; Serullas, *Ann. chim. phys.*, vol. 45, p. 270.

[5]Henry, *Liebig's Ann.*, vol. 81, p. 345.

[6]Vorlander and Schilling, *Liebig's Ann.*, vol. 310, p. 369; Nativelle, *J. prakt. chem.*, vol. 26, p. 404; Van Wyk, *Z. anorg. chem.*, vol. 32, p. 115; vol. 48, p. 4; Van Ernster, *Z. anorg. chem.*, vol. 52, p. 279; Kenny, Thesis, Mass. Inst. Tech.

[7]Kreider, *Am. J. of Sci.*, 3rd series, 1895, vol. 49, p. 443.

[8]Mathers, *J. Am. Chem. Soc.*, 1910, vol. 32, p. 66.

[9]Willard, *J. Am. Chem. Soc.*, 1912, vol. 34, p. 1480.

[10]Oechsli, *Z. Electrochem.*, 1903, vol. 9, p. 807.

[11]Bennett and Mack, *Trans. Am. Electrochem. Soc.*, 1916, vol. 29, p. 323.

and a copper coulometer. The voltage across the cell terminals was recorded at intervals by a voltmeter.

Preliminary experiments showed that the amount of perchloric acid produced by the electrolysis of hydrochloric acid depended upon: (1) Duration of electrolysis. (2) Current density on the anode. (3) Concentration of HCl. (4) Temperature of electrolyzing cell. (5) Anode material.

The usual procedure was therefore to keep four of these factors constant and vary the fifth over a sufficient range. For example: all the above conditions were kept constant except the duration of electrolysis. This factor was varied so that data were obtained to determine the products of electrolysis from the time when approximately 3 ampere-hours had passed, to the time when all the available acid had been converted to perchloric acid. Thus, successive portions of 150 c.c. of HCl were electrolyzed at constant current density, acid concentration, temperature and anode material at different values of ampere-hours passed until complete data had been obtained for these conditions.

The next step was to change the current density and make another series of electrolyses, keeping this new value of current density constant with the other factors, while a new set of data was being obtained at various ampere-hours.

When the current density had been varied over a sufficient range, the concentration of the acid was changed and the above-described system of runs was repeated with varying current density and ampere-hours for this new concentration of acid.

At the completion of the electrolysis, the electrolyte was removed from the cell and shaken with mercury to remove the free chlorine. After filtering out the mercurous chloride, the filtrate was analyzed for chloride, chlorate and perchlorate. Three aliquot portions were pipetted off into Erlenmeyer flasks. The first was titrated with N/10 NaOH, using phenolphthalein, to give the total acid. The second portion was acidified with HNO_3 and titrated for chloride by adding an excess of $AgNO_3$, boiling to coagulate the AgCl and titrating the excess of silver nitrate with ammonium sulphocyanate, using ferric-ammonium alum as an indicator. The third portion was acidified with dilute nitric acid and an excess of a 10 per cent solution of ferrous sulphate added to reduce the chloric acid. After boiling for 10 minutes an excess of silver nitrate was added and the chloride-chlorate chlorine determined as before. The perchloric acid was thus determined by difference.

The results obtained from a number of typical runs made with this apparatus are shown in the accompanying table. The volume of solution electrolyzed in each case was 150 c.c.

A study of the figures in the table shows:

1. That in dilute solutions, N/10, as much as 50 per cent of the original acid may be converted into perchloric acid, the larger part of the remaining acid being lost as chlorine.

2. That with increasing concentration, the per cent which can be thus converted rapidly diminishes, decreasing to 10 per cent in half normal solution. The loss as chlorine rapidly increases (approaching 100 per cent for concentrations over N/1).

3. The per cent of chloric acid, on the other hand, in the electrolyzed liquor increases with increasing initial concentration.

4. Increasing the current density 100 per cent (from 0.1 to 0.2 amp. per square centimeter), increases the percentage conversion to perchloric acid slightly (from 41.6 to 44 per cent), while the percentage energy increase is much greater (25.8 to 37.9 watt-hours).

5. Increasing the temperature from 20 to 40 deg. tends to decrease the perchloric acid yield, but to increase that of chloric acid present. The energy consumption is at the same time decreased.

With the above results as a guide, the design of a new type of cell was next undertaken in which the oxidation of hydrochloric acid to perchloric could be carried out continuously.

Final Form of Cell

Without entering into the details of the construction and operation of a number of forms of apparatus which developed difficulties for long-continued operation, the final form only, which gave excellent service, will be here described.

The form of the cell was that of a long, narrow rectangular trough flared at the top. Its dimensions were 18 in. long by 6 in. deep by 1 in. wide (45.7 x 15.2 x 2.5 cm.). It was hammered out of a sheet of silver 30 x 14 x 0.005 in. thick (76 x 35.5 x 0.013 cm.), and was without any seams. This trough, which served as the cathode, was reinforced and supported in a copper mesh frame (two wires to the inch of No. 16 B. & S. gage (0.13 cm.), to which it was soldered at several

DATA ON ELECTROLYSIS OF DILUTE HCl SOLUTIONS

Amp Hr.	Current Density Amp. per Sq.Cm.	Normality of HCl at Start	Normality of HCl at Present	Per Cent HCl Present	Per Cent HCl Lost by Chlorine Evolution	Per Cent HCl Converted to $HClO_3$	Per Cent HCl Converted to $HClO_4$	Equivalent of $HClO_3$ per Liter	Equivalent of $HClO_4$ per Liter	Watt-Hours	Watt-Hours per Gram $HClO_4$ Produced
Temperature 20 Deg. C.											
4	0.137	0.0984	0.0138	14.0	41.2	1.50	43.0	0.00148	0.0423	30.0	47.4
5	0.137	0.0984	0.00806	8.20	43.5	1.00	48.0	0.00098	0.0472	38.1	53.9
6	0.137	0.0984	0.00384	4.00	46.0	....	50.0	.....	0.0492	46.1	62.6
4	0.137	0.251	0.0500	19.9	59.0	5.38	15.0	0.0135	0.0370	22.1	39.8
5	0.137	0.251	0.0310	12.4	62.0	3.75	20.0	0.0094	0.0500	28.5	38.9
6	0.137	0.251	0.0200	7.98	64.0	1.99	25.0	0.0050	0.0620	35.1	37.8
7	0.137	0.251	0.0110	4.38	65.4	0.50	29.4	0.0012	0.0736	41.7	37.8
4	0.137	0.510	0.160	31.4	60.9	6.45	2.36	0.0329	0.0120	17.5	97.2
5	0.157	0.510	0.110	21.6	65.6	5.66	4.96	0.0289	0.0253	22.6	59.6
6	0.137	0.510	0.073	14.3	70.2	4.90	7.61	0.0250	0.0388	28.0	48.1
7	0.137	0.510	0.0550	10.8	74.9	4.12	10.2	0.0210	0.0520	33.7	43.1
4	0.204	0.251	0.0570	22.7	57.0	2.15	17.9	0.0054	0.0450	27.3	40.5
5	0.204	0.251	0.0390	15.5	60.0	1.39	22.4	0.0035	0.0563	35.0	41.5
6	0.204	0.251	0.0290	11.6	62.5	0.70	26.8	0.0017	0.0672	43.0	42.7
7	0.204	0.251	0.0200	7.97	63.0	....	30.1	.....	0.0755	51.2	45.3
4	0.102	0.0984	0.0123	12.5	44.0	3.10	41.6	0.00305	0.0410	25.8	42.0
4	0.171	0.0984	0.0152	15.5	38.9	....	45.0	.....	0.0443	33.8	51.0
4	0.204	0.0984	0.0157	16.0	38.8	0.60	44.0	0.0006	0.0433	37.9	58.5
Temperature 40 Deg. C.											
3	0.137	0.217	0.0430	19.85	64.9	13.4	1.84	0.0290	0.0040	13.5	225
5	0.137	0.217	0.0182	8.39	72.5	13.9	6.2	0.0280	0.0135	25.0	123
8	0.137	0.217	0.0020	0.92	73.5	6.0	19.6	0.0130	0.0425	44.0	69

points. A silver outlet tube was welded in the bottom of the cell by silver solder. The cell was immersed in a water bath, a strong spray of cooling water being continuously sprayed over both sides of the cell from perforated pipes placed in the bath. By regulating the rate of flow of the spray, the temperature of the cell could be adjusted within wide limits. Sheet silver was finally chosen for the cell, after copper, iron, nickel, Monel, lead and silver-plated copper had been tried out, and all found to develop difficulties in long-continued electrolysis from the corrosive action of the chlorine.

In the endeavor to find a protective coating which would resist the action of chlorine outside the cell, paraffine, ceresin, shellac, asphalt, asphalt paint and a solution of Grade A Bakelite in amyl acetate were used. Of these the last, when properly applied, dried and baked at a temperature not exceeding 150 deg. C., proved very satisfactory.

The anode was of sheet platinum, approximately 5 x 16 in. (12.7 x 41 cm.) in area, and 0.0015 in. (0.0038 cm.) thick, suspended in the center of the cell from a heavy copper rod to which it was clamped. All copper parts and contacts were protected by Bakelite. The anode was held down in place by a glass rod and glass balls attached to the lower edge.

In a continuous run the hydrochloric acid flowed into the cell from a reservoir containing a stock solution and the electrolyzed liquor ran off into two 12-in. fused silica Vitreosil evaporating dishes arranged in cascade in which the perchloric acid was concentrated. The flow of the liquid was controlled by an automatic electric regulator, perfected by E. C. Walker and F. W. Hall. The evaporation was continued until a 60 per cent solution of perchloric acid which boils under atmospheric pressure at 160 deg. C. was obtained. For use in analytical work this solution was distilled; the product thus obtained contained only a slight impurity of silica accompanied by alumina which probably came from the evaporating dishes.

With a single cell of this type about 50 lb. of 50 per cent pure perchloric acid was made during the course of the investigation. The following data taken on one series of experiments illustrate the extent to which the original hydrochloric acid could be converted to perchloric acid:

Initial concentration of hydrochloric acid, 0.5 *N.*
Average current, 150 amp.
Average voltage, 8 volts.
Average current density (anodic), 0.16 amp. per square centimeter.
Average rate of flow of liquor through cell, 25 to 30 liters per hour.
Average temperature, 18 deg. C.

Run 1.

Concentration of HCl at end, 0.0179 *N.*
Concentration of $HClO_3$ at end, 0.0255 *N.*
Concentration of $HClO_4$ at end, 0.0738 *N.*

The product from this contained too great a percentage of chloric acid. It was therefore brought up to 0.5 normal by the addition of hydrochloric acid and again electrolyzed in the cell with the following results:

Run 2.

Concentration of HCl at end, 0.171 *N.*
Concentration of $HClO_3$ at end, 0.0089 *N.*
Concentration of $HClO_4$ at end, 0.2015 *N.*

This solution contained 20 g. of perchloric acid per liter. By again bringing up the acidity and electrolyzing, a solution of the following composition was obtained:

Run 3.

Concentration of HCl at end, 0.01117 *N.*
Concentration of $HClO_3$ at end, 0.0078 *N.*
Concentration of $HClO_4$ at end, 0.286 *N.*

In the first and worst case in which the original acid was subjected to electrolysis by passing once through the single cell, a yield of approximately 800 g. of 60 per cent acid per 24 hours at an expenditure of 28,800 watt-hours, or about 26 watt-hours per gram of acid (60 per cent), was obtained.

There is no doubt that better results could be obtained by the use of two cells, in the first of which the best conditions for the production of chloric acid were maintained—i.e., fairly strong acid, high temperature and medium density—while in the second the products of the first cell would be electrolyzed under the most favorable conditions for the oxidation of chloric to perchloric acid—namely, more dilute solution, low temperature and high current density.

The results obtained with our apparatus demonstrated, however, that a high grade of perchloric acid could be produced in quantity by the electrolysis of hydrochloric acid.[12]

In conclusion, it may be of interest to add that with the acid obtained the salts of the following metals were prepared: Strontium, zinc, copper, manganese, nickel, cobalt, iron (ferrous and ferric), tin, bismuth, gold, beryllium and uranium.

These salts are all very soluble in water, and with the exception of the ferrous, nickel, cobalt and zinc salts, are decidedly hygroscopic. The use of perchlorates, especially of the lead salt, for electroplating purposes is well known from the work of Mathers,[13] as they are very stable and not readily reduced by hydrogen. Ferrous perchlorate is also remarkably stable as regards oxidation.

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[12] The process has since been perfected and used by the Genesee Chemical Co., Batavia, N. Y., for the manufacture of perchloric acid.

[13] U. S. Pat. 931,944.

Material Handling as a Factor in Eliminating Industrial Waste*

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MODERN civilization is the direct result of the application of the principles of subdivision of labor. This in turn has resulted in labor-saving inventions, and material-handling devices have played an important part in this development. Yet today, in spite of equipment and methods now available, material is handled constantly in identically the same manner as in the early stages of civilization.

Why is this? In the opinion of the author, it is due to a number of influences, such as: (1) Ignorance of methods and equipment available. (2) Lack of standardization of materials, methods, containers to be handled to permit installation of and economical use of material-handling apparatus. (3) Insufficient comparative economic data. (4) Improper engineering. (5) Poor salesmanship and selling policies. (6) Lack of a central organization to educate the public and to act as a clearing house for economic and technical information.

There has recently been published an Encyclopedia of Material Handling, prepared by recognized authorities. This is a step in the right direction and it should prove of considerable assistance, particularly in eliminating ignorance of methods and equipment.

It is a well-recognized fact in industrial-plant operation that the last 20 per cent of operating efficiency is the hardest to obtain, and yet shows the highest return. Thousands of plants in this country do not show an operating efficiency of more than 50 per cent, as compared with those plants that have an operating ratio as high as the present state of the art will permit. There are many reasons for this low operating ratio, but we are concerned only with the losses due to inadequate and inefficient material handling.

Industrial costs are composed of the following factors: (1) Material, (2) production labor, (3) factory burden or overhead, (4) general administration expense and (5) sales expense.

As a usual thing, indirect or non-productive labor is charged out to factory burden. A very large portion of this labor is used in picking up, putting down and transporting material of all kinds. Hence one place to start in reducing factory burden is to reduce waste in labor and expense in this indirect-labor item by substituting adequate and properly adapted material-handling equipment and methods.

The initial test of any method, system or device should be an economic one. The question of will it pay should not be begged. Capital has been wasted, pioneers discouraged, the public bewildered because of undertakings not conforming to this test.

Hunt[1] postulates these principles as follows:

1. In handling material, perform only the handling operations that are absolutely necessary.

2. Perform these operations in the way that obtains the lowest cost.

When a simple plan for handling materials has been developed, the financial returns of the installation will, in the absence of labor difficulties, largely determine the wisdom of the installation. It may pay to install apparatus and it may not, according to conditions such as: (*a*) Constancy or intermittency of the work, (*b*) character of the operation itself and (*c*) results of analysis which follows.

A specific example of the saving effected by the introduction of proper methods of handling materials occurred in the case of a certain paper mill. The mill was 60 years old or more, and had grown around itself in a manner that presented a number of problems difficult to solve. After a policy for rehabilitation and extension had been worked out, it was possible to predict future material-handling costs, based upon improvements that would obtain under the rehabilitation plan and application of the proper material-handling equipment to the problems in hand. Table I illustrates the varied material to be handled, but one would need to know the physical handicaps at the mill to appreciate fully the necessity for and the difficulty of obtaining a right solution of the problem. The preliminary testing and checking of the equipment installed indicate that the savings will be readily obtained and in some cases exceeded as operating proficiency increases.

TABLE I. ESTIMATED ANNUAL COST OF PRESENT AND PROPOSED METHODS OF HANDLING MATERIAL IN A CERTAIN PAPER MILL
(Based on Average Quantities Consumed in Year 1919 and 6 Months 1920)

Material	Unit	Average Annual Consumption	Present Cost* Unit	Present Cost* Total	Estimated New Investment	Proposed Cost* Unit	Proposed Cost* Total	Annual Saving Unit	Annual Saving Total	Equipment Selected
Alum	Ton	207	$10.60	$2,862	$5,500	$1.87	$505	$8.73	$2,357	Locomotive crane and power mule
Ash disposal	Ton	4,800	2.08	10,000	15,000	0.42	2,000	1.86	8,000	Pneumatic conveyor
Bleach	Ton	875	2.80	2,450	.....	2.00	1,750	0.80	700	Locomotive crane and power mule
Clay (china)	Ton	1,800	4.48	8,064	11,100	1.60	2,880	2.88	5,184	Pneumatic conveyor
Lime	Ton	2,500	1.60	4,000	1,950	0.50	1,250	1.10	2,750	Pneumatic conveyor
Lumber: box	M.B.M.	1,000	4.85	4,850	400	2.25	2,250	2.60	2,600	Loco. crane and gravity conveyor
Lumber: stripe	M.B.M.	100	6.00	600	.....	3.50	350	2.50	250	Loco. crane and gravity conveyor
Pulp wood	Cord	10,000	4.10	41,000	60,000	1.67	16,700	2.43	24,300	Loco crane and pneumatic conveyor
Rosin	Ton	250	6.55	1,637	6,000	1.00	250	5.55	1,387	Loco. crane and power mule
Soda ash	Ton	545	2.40	1,310	500	0.50	273	1.90	1,037	Pneumatic conveyor
Sulphite pulp	Ton	5,500	4.10	23,000	14,000	1.95	10,500	2.15	12,500	Power mule
				$99,773	$114,450		$38,708		$61,065	

* The present costs include maintenance and repairs but no fixed charges, or other overhead items. The proposed costs include fixed charges of 20 per cent.

The public, industrial executives and business men generally are not in possession of sufficient data and economic facts to make them realize the astounding wastes going on all around. Engineers and manufacturers are largely to blame for this. The industrial executive usually knows how much per piece or per unit it costs to produce a given article, but rarely knows what it costs per unit to handle the materials entering into the manufacture of the article itself or the cost of handling the finished article. It is only recently that industrial plants have been designed or laid out on a material-handling basis.

If the manufacturer will get the engineer's point of view and the engineer the manufacturer's, and both will get the economic viewpoint, much good will result, fewer mistakes be made, and society and industry will benefit and prosper.

*Abstracted from a paper presented at the annual meeting, New York, Dec. 5-9, of the American Society of Mechanical Engineer and printed in *Mechanical Engineering* for December, 1921.

[1] "Handling Materials in Factories," by William F. Hunt.

American Practice in High-Speed Steel Manufacture

Impressions on American Tool Steel Manufacture Received on a Trip of Inspection Covering Several Plants —Importance of Pure Raw Materials and Metallurgical Control of All Steps in Process Is Emphasized

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IT MAY be interesting to recount impressions received during a trip of inspection, when eight of the largest tool steel mills in this country were visited, six of which are using the crucible process, the two others melting their high-speed steel in the electric furnace. Several of the mills using the crucible process are now experimenting with the electric furnace method of melting and are obtaining very satisfactory results. The majority of the high-speed steel produced in Europe is crucible melted, although Sweden is manufacturing some electric furnace high-speed steel. One must use just as pure raw materials in electric-furnace practice as it is necessary to use in crucible melting if as high-grade product is expected. Too many mills using electric furnaces have found to their sorrow that they cannot produce a dress suit from a pair of overalls!

The crucible process of melting steel dates back to centuries before Christ, when the Chinese melted steel in crucibles, but it is not the intention to sketch its history, absorbing though that subject may be. The process as used today by most of the large tool steel mills in this country, is as follows:

The base, usually high-grade muck bar,[1] is carefully weighed. Most mills use about 50 lb. to the charge (90 or 100 lb.). Before the war Swedish iron was used to a large extent in this country for the high-speed base, but has recently been difficult to procure. It is the opinion of some American manufacturers, and vigorously disputed by others, that just as good a base is made in this country. One of the mills informed me they were using "Armco" iron for the base, another mill uses a special open-hearth product; but the majority of the plants have found that muck bar, which is almost pure iron, gives the best results.

High-speed scrap is then weighed. This consists of crop ends, bar ends, etc., and usually makes up about 25 per cent of the charge, or 25 lb. In the medicine room, so called, the ferro-alloys are very carefully weighed and placed in pails, which also contain ground brick dust for a fluxing agent. These alloys, such as ferrotungsten, ferrovanadium, ferrochromium, ferromanganese and ferrosilicon, constitute the remaining 25 per cent of the charge. The ferro-alloys are refined in the electric furnace and usually carry the following percentages of the alloying element:

Ferrotungsten	75 to 85 per cent tungsten
Ferrovanadium	33 to 35 per cent vanadium
Ferrochromium	60 to 70 per cent chromium
Ferromanganese	75 to 80 per cent manganese
Ferrosilicon	48 to 50 per cent silicon

[1]Muck bar is genuine wrought iron. Impurities existing in pig iron of special grade are oxidized in a puddling furnace, the pasty iron sponge removed from the furnace in a ball or lump, most of the slag squeezed out, and the rough bloom resulting is rolled directly into a flat bar known as muck bar or puddle bar. Short pieces of muck bar are bundled, reheated to welding heat and rolled one or more times before being marketed in the form of wrought iron bar or pipe.

The proportion of the various alloys added as well as the amount of base and scrap used depends of course on the analysis required. Sometimes it is necessary to add wash metal—a white iron containing 3 to 4 per cent carbon, low in manganese, phosphorus, sulphur and silicon—to raise the carbon, while some mills add a small amount of charcoal. However, carbon is usually controlled by varying the amount of scrap and ferrochromium.

The material is now ready to be charged into crucibles. Crucibles used in America are made of a half-and-half mixture of flake graphite and binding clay. To prevent the graphite in the crucibles dissolving in the steel, they are usually lined with pure clay, lasting for four to six heats, the crucibles then being used for carbon tool steel melting. One mill superintendent states that he does not use this clay lining, but melts high-speed steel in crucibles which have been used for three or four melts of carbon tool steel. He says that steel absorbs only a very little carbon from crucibles which have been used several times.

Ferro-alloys, especially the ferrotungsten, are added near the center of the charge, to insure thorough mixing.

In order to maintain a neutral atmosphere, graphite covers are placed on the crucibles, which are then lowered into the furnace, each "hole" usually providing room for six crucibles. The size of the furnace is expressed by the number of crucibles it contains, such as thirty, thirty-six or forty-two crucible pot furnaces, and would contain, therefore, five, six or seven "holes." These furnaces are of the regenerative type, usually producer gas fired, and will melt the heat in 3½ to 4½ hours. After thorough melting, the heat continues for ½ hour more to permit gases in the molten steel to escape and to bring the steel to the proper casting temperature. This is known as the "killing" process.

Workmen then pull out these pots with large tongs. As it is necessary for them to straddle the open hole while it is at a temperature of around 3,000 deg. F. (1,650 deg. C.), they first wrap their legs and body in burlap, put on heavy shoes with wood and iron soles, drench themselves with cold water and after covering their hands and arms with water-soaked bags are ready for "pulling out." Considering the fact that these crucibles weigh over 100 lb., the job is not an easy one. Steel in these crucibles is then poured into molds or into a large preheated ladle and poured from the latter into the molds. The latter practice is more popular in this country and gives a more uniform analysis, ingot to ingot.

Raw materials used in electric furnace melting depend to a large extent on the available scrap supply. One large producer of electric furnace high-speed steel lists

the following as his raw materials: Muck bar, high-speed scrap, ferrotungsten, ferrochromium, ferrovanadium, ferromanganese, ferrosilicon, wash metal, limestone, lime, fluorspar, silica and ground electrodes. Another well-known manufacturer of high-speed steel states that limestone should never be used in the electric furnace process, for when it is present the heat melts with an oxidizing slag, causing a large loss in alloys. Lime in any form also slows the furnace working, and he states that there is always enough slag left in the furnace to take care of the subsequent heat while melting. He is also of the opinion that it is not necessary to introduce silica into the furnace, and that retort carbon should be used for carburizing in place of ground electrodes, because of the greater purity of the former. Such variations of opinion are given merely as a matter of record, without an attempt to appraise them critically.

Raw materials should be carefully analyzed, for it must be remembered that it is desirable to use just as pure materials in electric furnace melting as it is necessary to use in the crucible process. Anything showing high phosphorus, sulphur, nickel, arsenic, tin, copper, antimony or bismuth should not be used.

Usual Furnace Operations

Furnace operations, as usually carried out, are as follows: Limestone, if used, is first charged on the bottom of the furnace, wash metal next, then muck bar, high-speed scrap and ferrotungsten. The amount of high-speed scrap added usually runs from 30 to 40 per cent, one mill, however, claiming that 70 per cent scrap may be used if properly selected. Electrodes are then lowered, current turned on, and the steel melted, usually under neutral conditions. From 2 to 3 hours is required to bring the charge to a molten condition and approximately 600 kw.-hr. per ton of steel is consumed. A sample for analysis is usually taken at this point.

Slag is now removed and a new slag made of lime, fluorspar and ground electrodes, which maintains a strongly reducing atmosphere as well as a basic reaction toward the metal, thus eliminating oxygen and sulphur. A higher temperature is also usually used during this period to produce the desired chemical reactions. As soon as the bath is thoroughly deoxidized, ferrochromium, ferrotungsten and ferromanganese are added; ferrovanadium, the last alloy added, is usually introduced about 30 to 45 minutes before tapping; a short time before the heat is tapped ferrosilicon is introduced. Silica in small quantities is occasionally used to thin the slag. One large American mill usually makes five analyses during melting, the first being made as soon as the steel is melted, the others taken from time to time after recarburization, depending largely on the slag conditions. The last test is taken shortly before tapping. Five analyses obtained by this mill on one of their heats ran as follows:

	Test No. 1 Per Cent	Test No. 2 Per Cent	Test No. 3 Per Cent	Test No. 4 Per Cent	Test No. 5 Per Cent
Carbon	0.43	0.43	0.59	0.59	0.69
Silicon	....	....	....	....	0.29
Manganese	....	....	....	....	0.35
Sulphur	....	....	....	....	Trace
Phosphorus	....	....	....	....	0.019
Tungsten	17.29	....	....	....	18.48
Chromium	1.90	....	....	....	4.03
Vanadium	0.26	....	....	....	.98

When the heat is ready to tap, the slag is grayish white, containing carbide, and producing acetylene gas when thrown in water. One melter thinks that it is poor practice to work under a carbide slag, as the different ingots poured may show a carbon variation of from 0.05 to 0.15 per cent, depending on the strength of the slag. Other operators say it would be almost an impossibility to eliminate this carbide slag.

Hot electric metal must be "killed" the same as in the crucible process. Correct pouring temperature as well as the condition of the metal is determined by pouring and examining small test ingots, and when the metal is ready the furnace is tilted and the steel poured into a heated ladle. After the hot steel is permitted to stand in the ladle several minutes to allow the trapped non-metallic particles to rise to the surface, the steel is teemed into molds.

Mills making electric-furnace high-speed steel claim the following advantages for their process over the crucible melted product:

1. Any desired temperature can be obtained.
2. More accurate chemical control is possible.
3. Impurities in original raw materials may be eliminated.
4. Better mixing of ingredients is effected.

The advantages of the crucible melted high-speed steel over the electric furnace material are said to be as follows:

1. A more careful examination of base materials is required.
2. Steel is melted in small units.
3. A neutral atmosphere is maintained in the crucible.
4. Unsurpassed ingots are poured by hand.

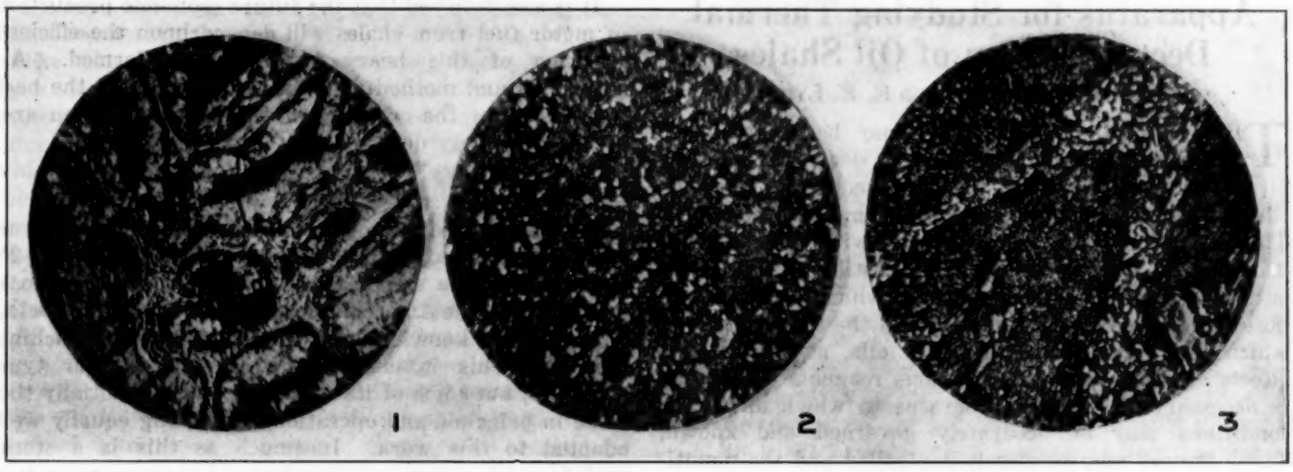
Ingot Practice

Liquid steel, produced from either of the above processes, is usually cast into split iron molds with solid bottoms. These molds are tapered, and set with the large end up. On top of these molds rest preheated hot tops, or "dozzles," fireclay shells whose outside dimensions are the same as the inside dimensions of the molds. These hot tops act as reservoirs holding molten steel to feed the shrinkage cavities and eliminate piping to a marked degree. Molds are smoked so as to eliminate surface defects on the ingot.

When the ingots have cooled sufficiently, they are stripped from the molds. At this point the practice varies in different mills visited by the writer. The majority immediately anneal the ingots after they are stripped so as to remove all casting strains and to refine the grain as much as possible. Some mills omit this annealing operation, thinking that no benefits are derived.

The ingots are usually sampled for complete analysis, and whether annealed or unannealed are then carefully examined for surface defects. Imperfections are ground or chipped out. A small corner is also usually broken off and the fracture examined.

Ingots are now charged into large heating furnaces, coal or oil fired, and allowed to remain until they have been thoroughly heated to a temperature of approximately 2,100 deg. F. (1,149 deg. C.). They are then hammered by large steam hammers and reduced to billets. The piped end is then cropped off, usually amounting to from 10 to 20 per cent of the weight of the ingot. Billets are again carefully examined for surface defects, usually the entire surface is ground, and a careful examination of a fractured surface is also made. Billets are then charged into reheating furnaces and heated through to the proper temperature for further reduction. In most cases billets are annealed



FIGS. 1 to 3

Fig. 1. Structure of high-speed ingot; 3½ in. square. × 300

Fig. 2. Structure of ⅞ in. hammered and annealed bar made from ingot of Fig. 1. × 300

Fig. 3. Undesirable segregations in 8½ in. hammered bar. × 300

before being reheated. Finishing to size is done either under hammers or in rolls. A short time ago some interesting experiments were conducted by Messrs. Andrew and Green of the Armstrong-Whitworth Co., England, to ascertain the comparative effect of hammering or rolling on the microstructure of high-speed steel, and no difference was observed, contrary to the widely held opinion that hammering produces a better product than rolling.

Finished bars are usually placed in large tubes, the ends sealed and the tubes then rolled into annealing furnaces, equipped with from four to twelve pyrometers connected to autographic recorders. Furnaces and contents are then brought up to from 1,500 to 1,600 deg. F. (816 to 870 deg. C.), held there for a considerable length of time, then slowly cooled in the furnace, an operation requiring from 2 to 3 days. It will usually produce a Brinell hardness of from 196 to 235, depending on the size of the material being annealed. A few mills use a packing material such as charcoal and ashes in the large tubes, but it is claimed that greater uniformity is obtained without this. A rapid method of annealing high-speed steel is to heat to 1,650 deg. F. (899 deg. C.) cool slowly to 1,300 deg. F. (704 deg. C.) and then air-cool. This will give a Brinell hardness of from 228 to 269, but the method is not used much in this country, as the consumers usually require a softer material.

Annealed bars are then carefully examined with a file for surface defects, their size measured, and both ends nicked and broken to examine the fracture for grain and pipe. Material is also tested for Brinell hardness. Most of the mills follow their steel through the different operations; it is identified with the proper heat number so as to know the analysis and history of the finished stock.

Fig. 1 shows the structure of a high-speed ingot as cast; Fig. 2 the bar produced from that ingot. The cellular structure has been entirely broken up by working, and a fine-grained structure produced with uniform distribution of carbides. A reduction of 85 to 90 per cent is required to break up the cellular structure and diffuse the envelopes. A section of an 8½-in. round high-speed steel bar in the annealed state is shown in Fig. 3. Carbide segregations and the envelope formation present in this annealed material have not been broken up by the manufacturing operations, nor were they subsequently eliminated in a hardening treatment, although the time and temperature were sufficient to overheat the steel. It is a well-known fact that envelope structures and massive carbide areas will not go into solution upon hardening, and quite often these are the cause of cracking or short life of tools made from them. Large high-speed rounds are never free from these carbide laminations, due to insufficient reduction; forged blanks are therefore finding wide use, as then the steel has been hammered in both directions, and if properly done, this breaks up this segregated structure.

One impression left on the writer after inspecting the various tool steel mills was the influence of the metallurgical department on the quality of the finished product. An accurate chemical control of the raw materials and the finished product is essential if a good, uniform product is to be manufactured. Metallurgical supervision of the casting, cogging and annealing temperatures insures material properly fabricated. In one of the large mills the metallurgical department had full control of all inspection. All of the mills visited had adequate chemical laboratories, and in the majority of cases well-equipped physical testing departments and metallographic laboratories. It was quite noticeable that in some the metallurgical equipment was not used nearly as much as in some of the other mills visited, and I might add that the latter were the plants whose products are ranked among the best in the country.

One often hears it said, mostly by men connected with the tool steel industry, that the analysis of high-speed steel is no indication of its cutting qualities. This statement is true, for in more than one instance two different brands of high-speed steel, with approximately the same analysis, have shown altogether different cutting qualities. This does not mean, however, that the analysis specification is not important and should not be enforced. A large number of rejections have been made because of insufficient carbon, tungsten or vanadium, for such material would surely produce inferior tools. It is, of course, a mistake to purchase high-speed steel under a chemical analysis only, as the microstructure, Brinell hardness and fracture in hardened bar are of such importance that they should be included in the specifications. Yet control of the chemical composition is a step toward uniformity, which is of great importance to any steel product.

Apparatus for Studying Thermal Decomposition of Oil Shales

By Ralph H. McKee and E. E. Lyder

THE distillation of oil shale may be accomplished in almost any kind of a heating device from which air is excluded and which can be raised to the temperature of decomposition of the pyrobituminous[1] substance. The results obtained usually vary with each method used and the manner in which the distillation is carried out. For a study of the manner in which shales decompose under the influence of heat and the temperature at which they break down to form oils, as well as the effects of steam, gases and various reagents on them it is necessary to have an apparatus in which all of the conditions may be accurately governed and known. These factors may be closely controlled and the quantities measured by means of a small rotary furnace described in this paper. The heating is done by gas, which makes it applicable to almost any laboratory, and the temperature is controlled automatically, as will be indicated later.

The method and apparatus may be used for test work both for oil yield and ammonia, but they are particularly adapted for the study of conditions under which the shale decomposes and the apparatus is on a sufficiently large scale to give results approximately parallel to those obtained in commercial retorting.

Most methods used to date involve starting the shale at relatively low temperature and continually raising the temperature until the oil is completely removed. Recent work has shown that important information may be gained by heating the shale to definite and known temperatures. For instance, it has been shown by the authors[2] that shale pyrobitumens decompose at quite definite temperatures to form bitumens and that the decomposition takes place over a relatively short range (within 10 deg. C.). Different shales may have different temperature ranges and the determination of these may be important.

[1] The term pyrobitumen (after Abraham, "Asphalt and Allied Substances") is used to designate the material in shale which, on destructive distillation, yields bitumens.

[2] "Thermal Decomposition of Shales," *J. Ind. Eng. Chem.*, vol. 13, p. 613 (1921).

It is also believed that the future economic production of motor fuel from shales will depend upon the efficient cracking of this heavy bitumen first formed. An apparatus and method adopted to the study of the best conditions for the cracking of this heavy bitumen are, accordingly, very desirable.

Retort

The retort used was of the horizontal rotary type, one which when filled with ¼-in.-mesh shale held about 25 lb. The furnace and heating equipment are the stock type made by the American Gas Furnace Co. of Elizabeth, N. J., and are known as that company's heating machine No. 84. This is one of the company's older type machines, but some of its newer ones are essentially the same in principle and operation, thus being equally well adapted to this work. Inasmuch as this is a stock type furnace, a detailed description is unnecessary, but a general description of the furnace and a detailed discussion of the modifications adapting it to work with oil shale are desirable and will be given.

A drawing of the furnace and complete set-up is shown in Fig. 1. Briefly, the furnace is a steel cylindrical shell, about 3 ft. long with 4-in. fireclay insulation, inside of which is a series of burners and a rotating tube in which the shale, in a wire mesh cartridge, is placed. The heating compartment *B* contains the burners, ten in number, arranged five on a side and at the top of the furnace, as shown in the illustration. It is heated by gas blasted with compressed air (about 4 lb. pressure). The gas and air are led in through the pipes *b* and *b'*.

Temperature Control

The heating is closely controlled by means of a heat regulator *E*, which is the same as is used on some assay furnaces. It is made by the same company. This regulator is operated by compressed air as power taken from the air line and controlled by means of a base-metal pyrometer *p*, which extends into the firebox proper. This base metal pyrometer, being subjected to the direct heat of the flame in the firebox, makes the apparatus very sensitive and the control, therefore, quite accurate. There was found no difficulty in controlling

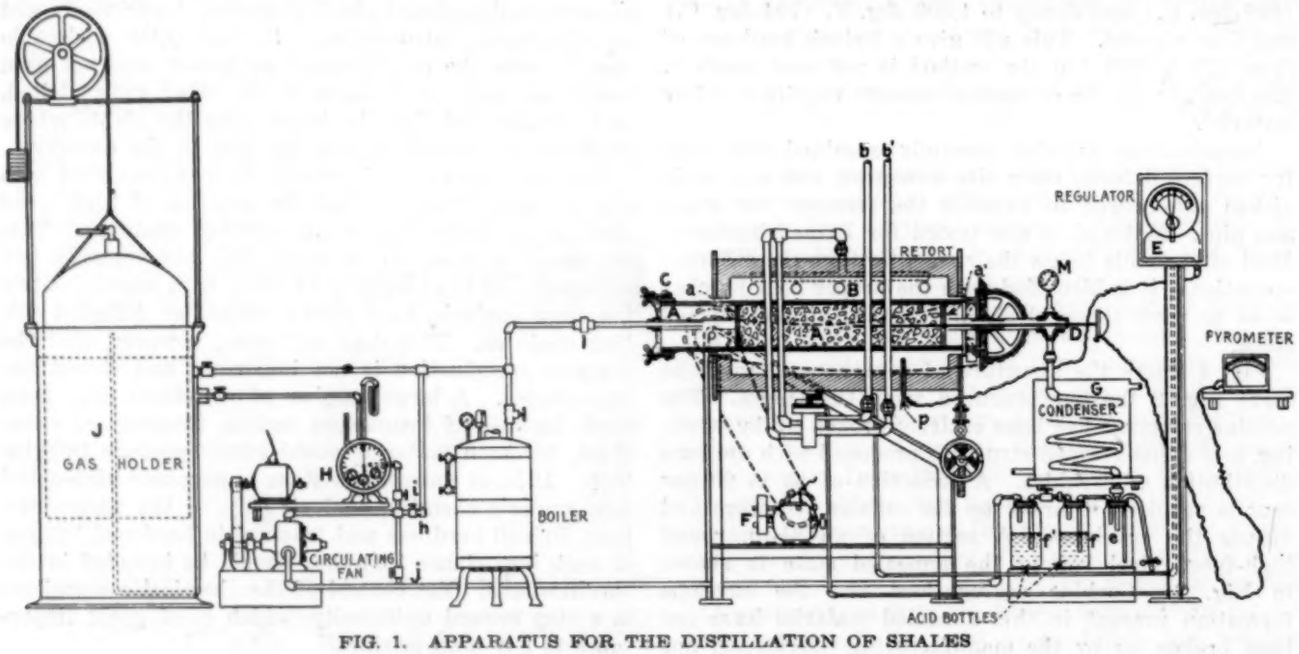


FIG. 1. APPARATUS FOR THE DISTILLATION OF SHALES

the temperature on the interior of the furnace, as measured by the pyrometer *D*, to within 10 deg. C.

The tube *A*, which is revolved by the motor *F* geared by a sprocket and bevel gear, as shown in the figure, extends through the furnace. It is 48 in. long, 7½ in. internal diameter, and ½ in. wall. The material of which this particular tube was made is nichrome, but the material usually supplied with the furnace is iron, and for shale distillation processes iron is adequate. Each end of the tube is closed off by heads fastened on by set-screws and thumb-screws, as shown. Stuffing boxes are provided at either end in order that the gases may be carried in and the vapors carried out without the admission of air. In order to confine the shale to the zone between the burners, perforated plates *a* and *a'* were set in. These were held in place by 1½-in. tubes screwed into the end plates. These tubes were perforated so that the gases collecting behind the plates would be carried out by the incoming steam or gas, thus avoiding dead gases. A space behind *a'* is also desirable so that the carbon and finely divided shale being carried out by the gases will settle before it passes into the vapor lines. The tube rotated at about 1 r.p.m.

Vapor Condensation

A convenient water-cooled condenser was made by using a galvanized iron tank 20 in. deep and about the same diameter. Through this was coiled about 15 ft. of ¾-in. pipe. In shale work it is often desirable to use air condensation before the vapors pass into a water condenser. This may be easily accomplished in this apparatus by erecting a 4-ft. riser where the pressure gage is shown at *M* and equipping it with a drain at the bottom and vapor line to the water condenser from the top. For this riser, 1½-in. pipe is sufficient.

The condensate was caught in glass bottles *e*, *f*, and *f'*, and the permanent gases carried back to measuring or circulating devices through the lead pipe as shown. The container *e*, in which all of the liquid products were caught, is fitted with a drain in order that they may be drawn off and measured from time to time. The containers *f* and *f'* may be filled with dilute sulphuric acid for washing out the ammonia if it is desired to determine this constituent. The boiler was a small low-pressure laboratory type furnishing the desired amount of steam. A circulating fan was installed, as it was desired to study the effects of various gases.

This equipment, supplemented by gas holders and measuring device such as wet test meter, etc., was found elastic enough to meet almost any condition desired in shale distillation work.

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Industrial Reconstruction of the French Davastated Region

A note in the November, 1921, issue of *Technique Moderne* shows some figures on the industrial reconstruction of the French devastated region. It is stated that of the 4,805 plants in this region employing 835,298 workmen before the war, only 3,284—i. e., 79.5 per cent—had resumed partial operation as late as Oct. 1, 1921, employing only 397,985 workmen—i. e., only 46.7 per cent of pre-war times. The percentages of workmen now employed in the devastated departments, with the pre-war figures as 100, are: Vosges, 62.2; Meurthe et Moselle, 56.3; Nord, 55.7; Ardennes, 45.3; Marne, 38.0; Aisne, 24.7, and Pas de Calais, 31.9.

Potash in the United States During 1920*

By M. R. Nourse

AT THE beginning of 1920 the fear of large imports of foreign potash sales still harassed the domestic potash industry, but as imports did not meet the demand and as prices on imported material early in the year were not materially lower than the prices on domestic salts, a large proportion of the sixty-six plants reporting production remained in operation throughout most of the year.

About 225,000 short tons of potash (K_2O) was imported in 1920. This, with the 48,077 short tons of domestic output, made the available quantity about equal to that normally used in each of the five years immediately preceding the World War. Because of the low prices received for their produce, many of the farmers of the country were unable to take up the promissory notes given by them for fertilizer in the spring of 1920 and were unable to buy the fertilizer they required in the fall. This condition, coupled with the abundance of potash on the market, resulted in a cancellation by the fertilizer-manufacturing companies of orders for domestic potash and greatly reduced the prices of all potash fertilizer materials. As a consequence all the Nebraska plants were closed by the end of December.

The price of potassium chloride (muriate) in the New York market ranged from $1.75 to $2.60 a unit during 1920. The net price for the same grade of material from 1911 to 1913 was 76c.

The approximate average prices per unit of potash (K_2O) of the domestic output f.o.b. plant for the same years are estimated as follows:

1915	$3.14	1918	$4.11
1916	4.37	1919	2.31
1917	4.29	1920	1.80

The sales for the year amounted to 139,963 tons of crude material, containing 41,444 short tons of potash (K_2O), valued at $7,463,026, an average price of $1.80 a unit. The stocks reported on hand at the end of the year were 32,378 short tons of crude material, containing 8,999 short tons of potash.

The plants operating for the primary purpose of producing potash—most of those utilizing brines, alunite, silicate rocks and wood ashes—produced 39,877 tons of potash (K_2O), or about 83 per cent of the total. The output of those producing potash as a byproduct was 8,200 short tons of K_2O.

Salines

Seventeen plants were in operation in 1920 for the extraction of potash from natural brines. Eleven of these were in the alkali-lake region of western Nebraska (two plants were operated by one company), three were in California and three in Utah. As in several former years, the alkali-lake region of western Nebraska produced more potash than any other locality; the individual plant producing the largest quantity of potash (K_2O) was that of the Utah-Salduro Co. at Salduro, Utah. Some of the plants producing potash from natural brines were operated throughout the year, but by the end of the year all the Nebraska plants and

*Advance Sheets Mineral Resources of the United States, 1920—Part II.

TABLE I. POTASH PRODUCED IN THE UNITED STATES, 1915-1920, CLASSIFIED ACCORDING TO SOURCES

Source	1915–16		1917		1918		1919		1920	
	Crude Material (Short Tons).	Available Content of Potash (K_2O) (Short Tons).	Crude Material (Short Tons).	Available Content of Potash (K_2O) (Short Tons).	Crude Material (Short Tons).	Available Content of Potash (K_2O) (Short Tons).	Crude Material (Short Tons).	Available Content of Potash (K_2O) (Short Tons).	Crude Material (Short Tons).	Available Content of Potash (K_2O) (Short Tons).
Mineral:										
Natural brines:										
Nebraska lakes	*13,910	4,068	61,053	14,558	116,662	28,854	36,176	9,072	65,245	20,934
Other brines	2,981	790	18,823	6,094	32,390	10,862	37,395	12,518	45,438	15,681
	16,891	4,858	79,876	20,652	149,052	39,716	73,571	21,590	130,683	37,515
Alunite	*3,036	1,518	7,153	2,402	6,180	2,621	6,599	2,294	4,151	2,976
Dust from cement mills	*5,435	504	13,582	1,621	12,652	1,549	11,665	1,258	10,168	1,147
Dust from blast furnaces	185	11	2,133	185	2,954	205	1,101	94	2,203	173
Silicate rocks	46	25	.....	.....	201	105	1,307	127	160	51
Organic:										
Kelp	*5,416	1,574	11,306	3,572	14,029	4,804	368	132	410	205
Molasses distillery waste	7,775	1,799	8,589	2,846	11,792	3,467	8,791	2,892	9,420	3,253
Steffens waste water from beet-sugar refineries	380	46	2,642	369	8,795	1,374	12,423	3,601	9,201	3,394
Wood ashes	†825	412	1,035	621	1,100	673	807	484	438	263
Miscellaneous industrial wastes	124	63	645	305	931	289	2	2	.....	.....
	40,113	10,810	126,961	32,573	206,786	‡54,803	116,634	32,474	166,834	48,077

*Production was made from this source in 1915. †Figures for 1915 not available. ‡Some of the material produced in 1918 was sold in 1919.

that of the Salt Lake Potash Co., which utilized brines from Great Salt Lake, were closed.

The pioneer company of the Nebraska district, the Potash Reduction Co.—also one of the pioneers of the American potash industry—made the largest production of potash salts in this district.

It is stated that the cost of producing a unit of potash (K_2O) at the Nebraska plants in 1920, including an item for depreciation, was a little more than $2. Doubtless the cost was considerably increased because of the dilution of the brines by the heavy rainfall in the spring and summer, which made concentration both difficult and expensive.

Of the three companies in Utah reporting a production of potash sales from brines in 1920 two utilized the waters of Great Salt Lake, and the third utilized the brines of Salduro Salt Marsh, in the extreme western part of the State.

The Salt Lake Potash Co., having a plant on the north shore of Great Salt Lake near Kosmos and producing potash from the waters of the lake by a solar evaporation process, has a yearly capacity of about 40,000 tons. Its product is a low-grade mixture of potassium sulphate and potassium chloride. At the end of the year the plant was closed because of the unsettled condition of the potash market, the high cost of labor and the difficulties of transportation. The Salt Lake Chemical Co., which has for a number of years been producing potassium salts at its plant at Burmester, on the south shore of Great Salt Lake, is a subsidiary of the Diamond Match Co.

The Utah-Salduro Co. at Salduro, 60 miles west of Great Salt Lake, produced more potash salts in 1920 than any other company in the United States. The deposit from which the potash is extracted has been described in former reports of the United States Geological Survey. The composition of the brine is similar to that of the artificial brines of the German potash works. Solar evaporation produces crude salts containing potassium, sodium and magnesium chlorides. These crude salts are boiled with hot brine and on cooling yield high-grade potassium chloride. Both high- and low-grade salts are marketed. Solar evaporation permits great saving of fuel. During 1920 the Utah-Salduro Co. was granted patent to 30,607 acres of land in the Great Salt Lake Desert.

Practically all the potash made from alunite in 1920 was produced by the Mineral Products Corporation, with plant at Marysvale, Utah, now owned by the Armour Fertilizer Works. An accident during the summer of 1920 retarded production somewhat, but new machinery designed to reduce materially the cost of producing potash was partly installed before the plant was shut down early in 1921. The demoralized condition of the fertilizer industry and the consequent lowered price of German sulphate, together with high freight rates, are given as the reasons for closing this plant, which produced a high-grade potassium sulphate and was a pioneer in the domestic potash industry.

The only commercial potash produced from silicate rocks reported to the United States Geological Survey for 1920 was a small quantity made by the Liberty Potash Co. from the wyomingite of Green River, Wyo. The plant of this company was run intermittently from November, 1919, to February, 1920. The product was a low-grade chloride. Since the plant was closed much additional experimental work has been done, and hopes are entertained of refinancing the project and putting it on a sound operating basis.

Only the Government experimental potash-kelp plant at Summerland, Cal., was in operation during 1920 on kelp as a source of potash salts. The capacity of the plant was not increased, but the energies of the force were directed to the development of byproducts, principally bleaching powder and iodine, both of which are now commercialized and placed on the market. The plant capacity for these materials, however, is not yet sufficient to put the experiment on a profitable basis. The output of potash from this plant has increased and the cost of production has steadily decreased. The output in June, 1920, was officially stated as 2 tons a day of 80 per cent muriate.

Status of the Luxembourg Iron Industry

In the review of the Luxembourg iron industry published in the Nov. 10 issue of *Stahl und Eisen* the following figures are conspicuous:

Locality	Blast Furnaces	Blast Furnaces in Operation June 30, 1921	Blast Furnaces in Operation Sept. 30, 1921
Belval	6	4	5
Esch	11	3	5
Steinford	3	1	1
Differdange	10	3	2
Dommeldange	3	0	0
Dudelange	6	3	4
Rodange	5	2	1
Rumelange	3	0	0
Total	47	16	18

Distillation Studies of Nitric Acid and Sulphuric-Nitric Acid Mixtures—I

Experimental Data on the Equilibria Existing Between Aqueous Nitric Acid Solutions and Their Vapors at Various Temperatures and Pressures—Effect of Dissociation of the Nitric Vapors —The Phenomena of Maximum Boiling Point

BY PAUL PASCAL
With the experimental assistance of Mr. Garnier

THE preconcentration of synthetic nitric acid from the arc process or the oxidation of ammonia, the final concentration of this acid, even the denitration of waste acids from nitrations, raise a very general question in regard to the equilibria between aqueous nitric acid solutions or mixed acids and their vapors at various temperatures and pressures.

Although in large-scale apparatus of high output this equilibrium is not rigorously attained, an exact knowledge of it has a great practical interest. It has, therefore, appeared worth while to assemble herein the results which we have collected on this question.

As thus far falling in this category one can scarcely but cite the partial work of Saposchnikow [*J. Phys. Chem. russe.*, vol. 37, p. 374 (1905)] on the HNO_3 vapor pressure of mixed acid, and that of Creighton and Smith [*J. Frank. Inst.*, vol. 179, p. 161 (1915) and vol. 180, p. 703][1] on the distillation of aqueous nitric acid and several nitric-sulphuric acid mixtures under various pressures. And yet this last work appeared just at a time when the results of our research began to find industrial application and a short time before the appearance in *Comptes rendus* [vol. 165, p. 589 (1917)] of a résumé of all our work.

This scarcity of numerical data relative to the commonest operations of the chemical industry has struck all physical chemists who have come in contact with the plant; it provides a free field for numerous and certain very interesting researches, particularly on ternary sulphuric-nitric acid mixtures, which we have specially studied.[2]

Study of the Binaries: Water, Nitric Acid

It is very difficult to avoid a partial decomposition when a concentrated nitric acid is boiled, and a false boiling point is always found on account of the dilution of the nitric acid vapor by its products of decomposition.

Aston and Ramsay [*J. Chem. Soc.*, vol. 65, pp. 167-73T (1894)] already, in their classical studies on surface tensions, observed that it was impossible to carry an almost colorless acid analyzing 99.8 per cent HNO_3 above 78.2 deg. C. without boiling, due to the formation in the supernatant atmosphere of a little nitrous product.

Küster & Münch [*Z. anorg. Chem.*, vol. 43, p. 350 (1907)] state that "absolute" HNO_3, of 100 per cent, colorless in the solid condition, already showed traces of decomposition from the time it melted.

It does not appear that Creighton and Smith were able completely to escape this inconvenience, and moreover in their experiments the pressure was measured at a distance from the boiling liquid, and hence there might be a marked difference (2 to 3 deg., sometimes 6 deg.) between the temperatures of the boiling liquid and the vapor emitted.

Since we could no more hope to prevent the dissociation, at least in the case of anhydrous acid, we preferred to determine its vapor pressure statically.

VAPOR PRESSURE OF PURE NITRIC ACID

The apparatus which was used was quite reminiscent of that employed in our work on the diamagnetism of organic compounds [*Ann. Chim.*, vol. 25, p. 304 (1912)].

The saturated vapor pressure of the liquid was measured by the increase in pressure resulting from its introduction into a space maintained at a uniform temperature and where the volume of the gas phase was maintained constant so that the correction of the expansion of the atmosphere could be avoided.

The increase in pressure was measured, below 30 deg., by a manometer of vaseline oil, freed from its alterable constituents by prolonged shaking with concentrated nitric acid; above 30 deg. by a column of mercury, protected by a layer of the same oil. All these operations were carried out under shelter from direct light.

The determinations offer no reliability above 75 deg.; often even before arriving at this temperature dissociation occurred, initiated by dust or by the too extended maintenance of an elevated temperature; even the vaseline oil was soon attacked. When working with a 100 per cent acid, prepared according to Küster & Münch, we obtained the figures in Table I, which agree well enough, with a slight extrapolation, with a normal boiling point lying between 86 and 87 deg., in the absence of all dissociation.

TABLE I. VAPOR PRESSURE OF 100 PER CENT NITRIC ACID

Temp., Deg. C.	Mm. Hg	Temp., Deg. C.	Mm. Hg
20	23	50	200
26	38	62	350
29	50	74	530
40	112	75	540

At low temperatures our figures are distinctly lower than those which Creighton and Smith obtained by measuring the boiling point at a given pressure; but at 50 to 60 deg. agreement is re-established and maintained.

HEAT OF EVAPORATION OF NITRIC ACID

It is known that Clapeyron's formula may be written:

$$L = \frac{T}{J} u' \frac{dp}{dT}$$

Translated from *Ann Chim.*, 1921, New Series, vol. 15, pp. 253 to 290, by F. C. Zeisberg, Chemical Department, E. I. du Pont de Nemours & Co.

[1] Note: The first of these is by Creighton and Githens, the second by Creighton and Smith. F. C. Z.

[2] See Pascal and his collaborators, *Bull. soc. chim.*, 1918-1920, *passim*.

if the specific volume of the liquid as compared with that of the saturated vapor is neglected. If the vapor is regarded as a perfect gas, we may write:

$$pu' = \frac{RT}{M}$$

M being the molecular mass; from which, finally:

$$L = \frac{RT^2}{JM} \times \frac{1}{p} \times \frac{dp}{dT}$$

It is thus found that at 86 deg. $L = 120$ cal. and at 75 deg. $L = 125$ cal., values which almost coincide with the direct determinations of Berthelot. It is noted, moreover, that the heat of vaporization, calculated from the vapor pressure curve, increases distinctly as the temperature decreases, as if at low temperatures the vapor suffered a notable polymerization.

The Boiling of Aqueous Nitric Acids

Several different but nearly similar apparatus were employed in the course of these experiments, all inspired by the twofold desire to obtain a sample of the vapors and the liquid without interrupting the distillation and to define as perfectly as possible the temperature and the pressure at which the two phases were in equilibrium.

In its most perfect form, achieved in the preliminary experiments, the distillation apparatus comprised a boiling vessel, a vapor cooler and a total condenser for the vapors, all of sealed glass.

A Würtz flask, of 5-liter capacity, half filled with liquid was heated on a sand-bath. It was entirely surrounded by an asbestos jacket provided with glass windows heated interiorly as needed by lamps with carbon filament. Thus all condensation of vapor was avoided before the cooler was reached. (See Fig. 1.)

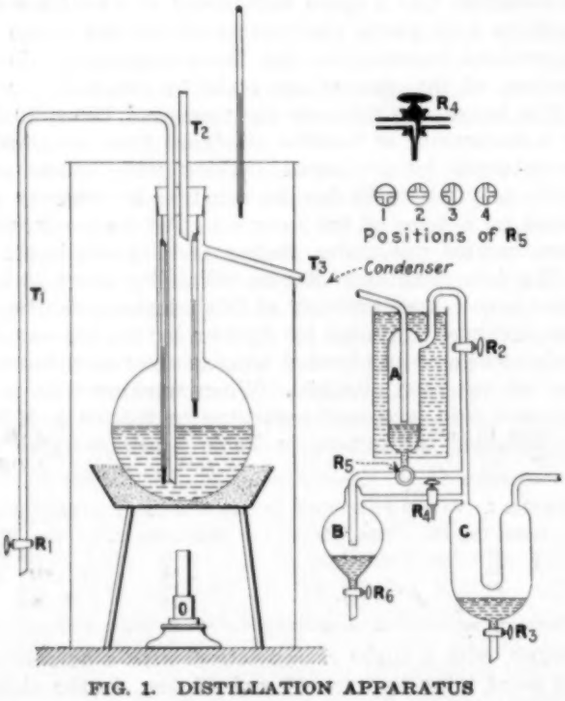


FIG. 1. DISTILLATION APPARATUS

A standpipe T_1 and a stop-cock R_1 served to empty and fill the apparatus; the tube T_2 connected the flask with a manometer and vacuum regulator; T_3 served to carry away the vapors.

Two thermometers were placed inside the flask; the bulb of the first was immersed in the liquid, that of the second extended only into the vapors. Under normal operation, before withdrawing any samples, they agreed within about 0.5 deg. and the upper part of the air-bath was about 5 deg. above this boiling point.

The cooler was a simple tube cooled on the outside by circulating water at 14 deg. and sealed directly to the condenser. This latter part of the apparatus consisted

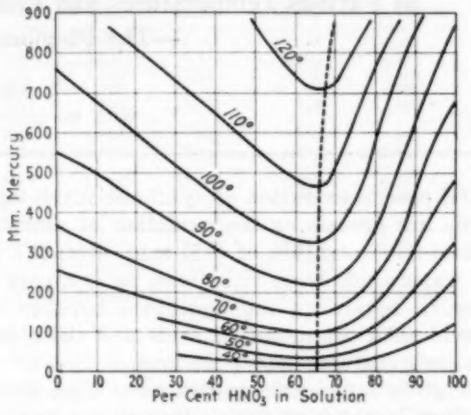


FIG. 2. BOILING POINT CONTOUR LINES

essentially of three reservoirs A, B, C; the first served as a measuring device, the second as a sampler, the third as a guard tube. To C was connected the water-jet pump which exhausted the apparatus, or the reservoir of compressed air used when boiling points above atmospheric pressure were studied.

The measuring tube A had a diameter of 2 cm. and a length of 10 cm. and was graduated; it was surrounded by a cooling bath (if necessary acetone and carbon dioxide snow) to condense all the vapors; B was a Cloez bubbling tube closed by a cock R_6.

The various cocks shown in the illustration are of different types. R_1, R_3 and R_6 are simple stop-cocks; R_4 is a stop-cock with an opening through the plug, which enables connection to be made with the atmosphere and B or C, to relieve the vacuum there; R_5 is a three-way cock, of which the openings may take various positions, as 1, 2, 3 or 4. (See Fig. 1.)

The flask being filled by suction through the tube T_1, R_1 is closed, R_2 is opened, R_6 is closed to the air and R_5 is turned into position 1. Heating is commenced and then as the boiling point, determined by a previous experiment, is approached, the water-jet pump is started to establish the desired pressure.

The ebullition is permitted to become regular to mix the liquid thoroughly and 4 to 5 c.c. at least of liquid is collected in A to rinse the apparatus well. This rinsing liquid is evacuated to the guard tube C by closing R_2 and setting R_5 in position 4, and immediately thereafter the two cocks are replaced in their original positions.

If at this time both thermometers in the Würtz flask indicate the same constant temperature, 2 or 3 c.c. of liquid is collected in the graduated tube, but this time is allowed to pass into the sampler by closing R_2 and putting R_5 in position 3.

After this operation R_5 is replaced in position 4, R_2 is reopened and by means of R_4 the sampler B is connected with the atmosphere, in order that the rinsing acid wetting its walls may be removed through R_6. A new portion of liquid is then transferred to the sampler, now well rinsed by the condensed acid, by repeating the above operation, and is withdrawn for analysis.

The measuring tube A, in short, serves to measure

TABLE II. DISTILLATION EQUILIBRIA FOR THE SYSTEM NITRIC ACID:WATER

Pressure, Mm. Hg	Boiling Pt., Deg. C.	Liquid HNO_3	Liquid NO_2	Vapor HNO_3	Vapor NO_2
Nitric Acid of About 25 per Cent					
190	65.5	23.8	<0.1	1.40	<0.1
237	72	24.0	<0.1	1.71	<0.1
465	93	24.6	<0.1	1.80	<0.1
566	100	24.0	<0.1	2.20	<0.1
760	106.5	24.2	<0.1	2.16	<0.1
870	115.5	25.2	<0.1	1.6	<0.1
Nitric Acid of About 34 per Cent					
40	40.2	36.0	<0.1	5.2	<0.1
116	59.0	33.1	<0.1	5.0	<0.1
318	87.5	33.2	<0.1	4.95	<0.1
458	97.5	34.0	<0.1	5.1	<0.1
570	104.0	33.0	<0.1	5.3	<0.1
680	108.5	32.99	<0.1	4.8	<0.1
760	112	33.0	<0.1	5.9	<0.1
Nitric Acid of About 50 per Cent					
40	45.8	51.0	<0.2	21.2	<0.2
116	66.5	50.0	<0.2	20.0	<0.2
317	95.0	49.2	<0.2	18.5	<0.2
458	105.5	50.5	<0.2	21.2	<0.2
570	111.0	49.8	<0.2	16.0	<0.2
760	118.5	49.8	<0.2	19.85	<0.2
870	124.2	50.2	<0.2	15.2	<0.2
Nitric Acid of About 60 per Cent					
40	52	61.0	<0.2	50.02	<0.2
116	70.2	60.65	<0.2	42.0	<0.2
317	98.5	61.0	<0.2	45.0	<0.2
353	104	61.2	<0.2	50.2	<0.2
463	109.5	60.98	<0.2	50.4	<0.2
517	112.5	60.85	<0.2	50.5	<0.2
553	113.5	61.2	<0.2	51.0	<0.2
622	115.5	61.2	<0.2	50.1	<0.2
670	117.5	60.95	<0.2	50.02	<0.2
725	120.5	61.0	<0.2	45.2	<0.2
763	121.6	61.0	<0.2	41.0	<0.2
Nitric Acid of 65 to 68 per Cent					
40	52.6	64.96	<0.2	65	<0.2
116	72.0	66.2	<0.2	65.9	<0.2
116	72.1	66.4	<0.2	66.4	<0.2
324	102	64.0	<0.2	50.0	<0.2
458	109	67.6	<0.2	66.9	<0.2
465	110.1	65.6	<0.2	64.95	<0.2
574	113.9	68.2	<0.2	68.10	<0.2
760.2	121.9	68.(	<0.2	68.4	<0.2
870	126.0	64.5	<0.2	58.9	<0.2
870	126.3	66.62	<0.2	65.10	<0.2
1,010	130.6	65.19	<0.2	65.10	<0.2
Nitric Acid of About 70 per Cent					
40	52.0	70.2	<0.2	85.0	<0.2
116	71.5	70.0	<0.2	86.2	<0.2
325	98.5	70.2	<0.2	79.2	<0.2
408	104	69.9	<0.2	80.2	<0.2
458	108	69.5	<0.2	80.0	<0.2
570	113.5	69.9	<0.2	77.2	<0.2
754	121	70.1	<0.2	84.0*	<0.2
Nitric Acid of About 75 per Cent					
40	47.6	74.72	0.35	94.80	0.31
116	67.0	74.52	0.35	90.77	0.31
325	93.0	75.52	0.35	89.57	0.35
408	103.0	74.62	0.35	86.56	0.35
540	110.0	74.02	0.35	94.56	0.35
760	118.0	75.12	0.35	91.50	0.35
Nitric Acid of About 80 per Cent					
40	43	79.81	0.21	97.78	<0.2
116	56	81.71	0.21	97.6	<0.2
458	91	81.70	0.21	97.98	<0.2
570	98	80.70	0.22	96.58	<0.2
760	112	79.73	0.22	96.7	<0.2
870	120.5	80.40	0.22	95.6	<0.2
Nitric Acid of About 85 per Cent					
40	38	84.45	0.41	98.35	0.41
116	52.5	85.45	0.40	98.75	0.51
345	78	84.45	0.40	98.45	0.31
458	84	84.65	0.40	98.65	0.2
570	92	84.65	0.40	98.15	0.2
760	99	84.65	0.40	97.45	0.2
Nitric Acid of About 90 per Cent					
40	32.5	89.52	0.5	99.84	0.1
116	47.5	90.05	0.4	99.25	0.5
315	63	90.92	0.5	99.59	0.23
458	75	90.59	0.3	99.66	0.1
570	80.3	90.69	0.3	99.63	0.2
760	90.5	89.65	0.4	99.41	0.2
870	100.0	91.6	0.4	98.5	0.2
Nitric Acid of About 95 per Cent					
40	29	94.52	0.35	99.43	0.4
116	43.5	94.92	0.28	99.65	0.25
458	69	94.67	0.31	99.62	0.2
760	85.5	95.38	0.45	99.63	0.2
870	90.5	95.0	0.45	99.69	0.2
Nitric Acid of About 98 per Cent					
40	27.5	97.62	0.28	99.47	0.31
116	41.5	97.50	0.29	99.33	0.41
315	59.0	97.64	0.41	99.47	0.38

*This appears to be a typographical error in the original article for 74.0.—F. C. Z.

the volume of liquid distilled during these operations and permits a determination of the average composition of the acid which furnished the liquid used for the analysis, owing to the knowledge which we have of the composition of the acid remaining in the distilling flask.

In order to make our results more expressive, we have assembled the results in Table II by grouping under the same head the acids whose composition is about the same. Each partial table thus practically gives the vapor tension curve of the acids of different strengths, and as the pressures have practically the same value in each group, we have at a glance the composition of the liquids and the vapors in equilibrium with them under these pressures at all the temperatures of our experiments. We have given in the "vapor" column the composition of the condensed liquids; they occasionally contained nitrogen peroxide in small quantity, but the resulting proportion of this substance is not necessarily exactly like that which existed in the atmosphere of the apparatus.

It is possible, moreover, to correct for the slight variations in strength and pressure for a single series by tracing the surface of the boiling points θ, which has the concentrations c for abscissas and the pressures p for ordinates. Fig. 2 gives the contour lines of this surface projected on a horizontal plane of reference.

Vertical sections of this surface, parallel to the horizontal axes of co-ordinates, represent either the curves

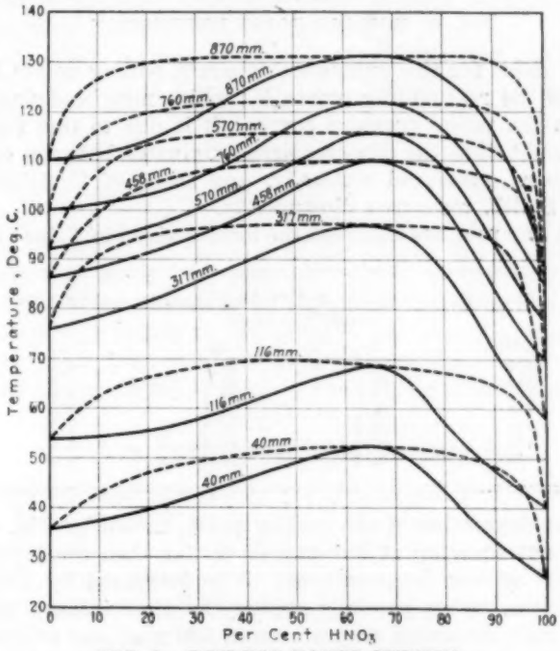


FIG. 3. BOILING POINT CURVES

of vapor pressures corresponding to a given strength, or the boiling point curves as a function of the strength, for a given pressure.

The system of original curves, projected upon the plan θp, bends back upon itself around the hinge formed by the curves which correspond to 65 to 68 per cent HNO_3, strengths for which the existence of a maximum boiling point is observed. The boiling point curves as a function of the strength are shown by the groups of Fig. 3, on which have been plotted the curves relating to the average pressures used in our experiments—namely, 40, 116, 317, 458, 570, 760 and 870 mm. This graph is completed by the vapor curves (dotted) obtained in the same experiments.

Dissociation of the Nitric Vapors

In all the preceding experiments it was impossible to prevent a partial dissociation of the vapors as soon as the strength of the acid exceeded 58 per cent HNO_3 and the temperature 50 deg. C. When at the same time both of these limits were exceeded, the atmosphere of

the apparatus became slightly colored and there distilled over a mixture of unaltered nitric vapors, oxides of nitrogen, oxygen and water vapor, in which the partial pressure of nitric acid was necessarily below the value indicated by the manometer. There must then be produced an apparent lowering of the boiling point of the acid supposedly distilling without decomposition, and only the "natural" boiling point is observed, to adopt the expression so frequently used by the Dutch school.

Moreover, a small extrapolation of the preceding boiling point curves to the co-ordinate for anhydrous nitric

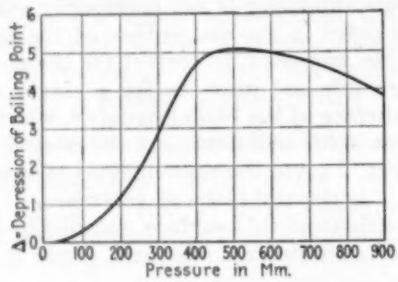


FIG. 4. BOILING POINT DEPRESSION

acid yields for this substance apparent boiling points E_a below the real boiling points E_r, which may be deduced from the vapor pressure curves; it is due to this fact, no doubt, that the disagreement originates between our numbers, measured statically, and those of Creighton and Smith, measured dynamically.

At any rate, we observed the figures given in Table III.

TABLE III. BOILING POINT DEPRESSION CAUSED BY DISSOCIATION

P_r, Mm.	E_r	E_a	Δ
870	91.0	87.0	4.0
760	86.5	82.0	4.5
570	77.5	72.5	5.0
458	70.5	65.5	5.0
317	60.0	56.8	3.2
116	40.4	40.0	0.4
40	26.2	26.2	0.0

The depression of the boiling point, shown by Fig. 4, does not show up at low pressures, for then the liquid distills at low temperatures; it is decreased by high pressures, which partially oppose the dissociation; the maximum deviation occurs around 500 mm. and attains a value of 5 deg. We have indicated a slightly higher depression in a preliminary note in *Compt. rend.*, vol. 165, p. 589 (1917).

Maximum Boiling Point

We naturally also encountered the well-known phenomenon of a maximum boiling point, corresponding to the time when the acid is emitting a vapor of the same composition as the liquid.

Varying the pressure modifies both the temperature at which this phenomenon occurs and the concentration of the acid which gives rise to it. Thus, we have observed the following results:

Pressure, Mm. Hg	Max. Conc., per Cent HNO_3	Max. Temp., Deg. C.
40	65.0	52.6
116	66.4	72.1
317	66.4	99.0
458	66.4	109.0
760	68.4	121.9
870	68.4	125.5

These values agree with those of Creighton and Smith, who determined, at three different pressures, the final composition of the acid obtained by distilling various acids of an initial concentration lying between 60 and 80 per cent, thus:

Pressure, Mm. Hg.	Concentration	Temperature, Deg. C.
760	68.18	121.7
360	67.15	99.9
110	66.8	74.2

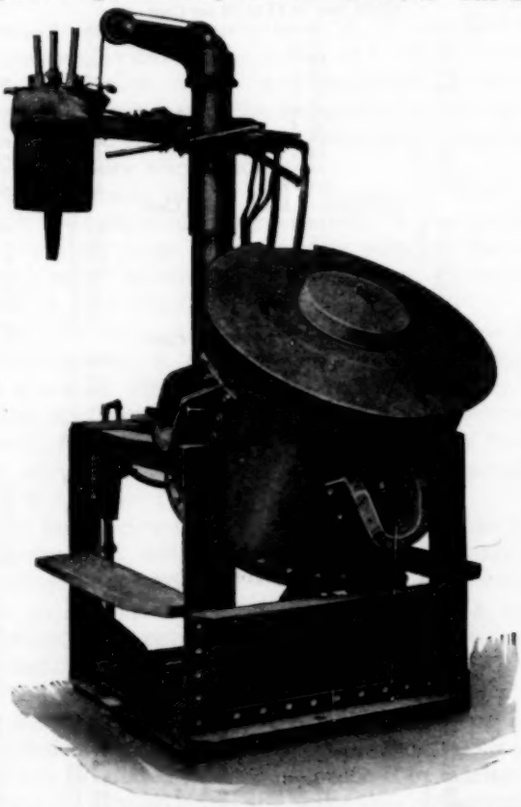
Diminution of the pressure thus displaces the maximum slightly in the direction of a lower nitric acid content. (See Fig. 2.)

Scientific Faculty of Lille.

(Part II, dealing with the system water: nitric acid: sulphuric acid and the practical application of these data, will be published in a subsequent issue.)

The Repel-Arc Furnace

THE Repel-Arc furnace[1] essentially consists of a metal framework supporting the furnace bowl and a mast which carries the electrode holder or torch. The frame is substantially made of standard shapes, riveted together. No foundation is required, except in the 1- and 1½-ton sizes. The bowl is made of boiler plate, with seams riveted. It is mounted on trunnions so that it can be tilted for pouring. Small furnaces are tilted by hand; the larger sizes by motor and screw. The bowls



REPEL-ARC FURNACE IN OPERATION IN A FOUNDRY SPECIALIZING IN SMALL STEEL CASTINGS

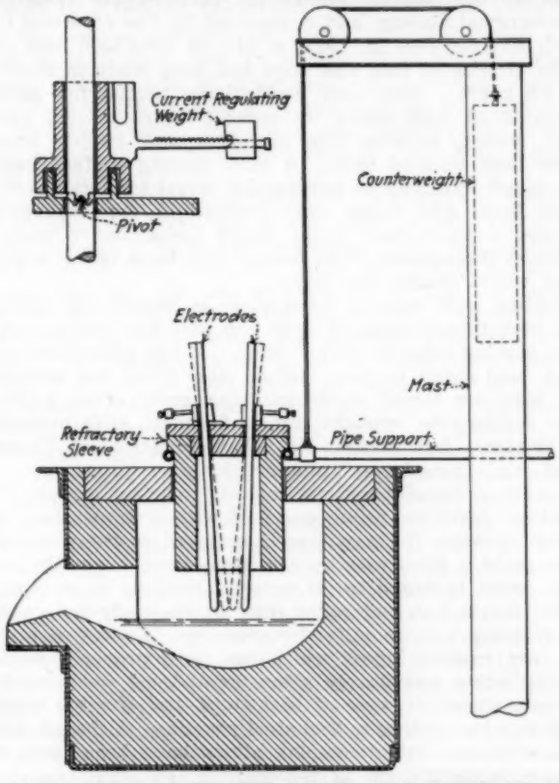
are made amply large, to admit of a thick lining, so as to keep heat losses at a minimum. The roof is made of firebrick.

Supported from the mast arm and counter-weighted so that it can be easily raised and lowered is the heating element, sometimes called the torch. This consists of a cylinder with one end closed, made of crucible material. Through the closed end of this cylinder are three round holes in which are placed cast alloy supports for the carbons or electrodes. Each of the three electrodes is

[1] S. von Schlegell, U. S. Pat. 1,352,541, Sept. 14, 1920.

carried in a sleeve which rests on the support so as to be pivoted or be free to swing. They are counter-weighted so that the lower ends swing into contact when the current is off. This simple expedient of mounting the carbons so that they are free to swing to and from each other makes the furnace self-regulating.

On account of the fact that the furnace is three-phase and automatically self-regulating, no special transform-



A CROSS-SECTION OF THE REPEL-ARC FURNACE AND ENLARGED SECTION OF AN ELECTRODE HOLDER, ILLUSTRATING THE PRINCIPLE OF OPERATION

ers are required. It can be connected to any 220-volt, three-phase motor supply circuit of proper capacity.

The instant the switch is closed the electrical repulsion and rapid evolution of gases between the carbons force them apart and draw the arc. If the current tends to increase, the carbons are forced further apart, increasing the length of the arc and keeping the current from rising. If the current reduces, the carbons move closer together, shortening the arc and keeping up the current. If the power is shut off and turned on again, the arc is immediately re-established.

Both Direct and Indirect Arc

A distinct advantage of this new furnace is the fact that it can be operated both as a "direct arc" and an "indirect arc" furnace, which adapts it to the melting of metals of different kinds. The electrode holder can be raised and lowered as a unit. When melting metal of high volatility, the arc can be maintained entirely between the electrodes at the desired distance above the metal. Again, when melting down metal requiring greater heat, the arc can be lowered so as to take place wholly or partly between the electrodes and the metal itself. After the metal is molten, the arc can be maintained entirely between the electrodes and the molten mass if desired. In melting down a charge the arc is not broken by the falling away of the metal as it is melted, because the arc is still maintained from electrode to electrode if it ceases between the electrode and the metal. This constant maintenance of the arc makes the operation of the furnace steady and uniform.

Quick Pouring and Charging

Again, when ready to pour, the heating element is raised in an instant and swung out of the way. The shell can then be tilted forward for pouring. As soon as the pouring is completed, the next charge can be put through the roof opening, the electrodes swung into place and the furnace started again. This saves time and heat, prevents breaking electrodes and makes it possible to repair the lining without disturbing the roof. With the charge prepared in advance, it is an easy matter to pour, recharge and start a 500-lb. furnace in 5 minutes.

To adjust the furnace so that it draws any given amount of power from the line, it is only necessary to move the adjustable counter-weights on the electrode holders. This makes it possible to change the heating rates at will. The vertical movement of the torch as a whole also makes it possible to maintain the arc at the desired distance from the metal, without affecting the electrical operation of the furnace.

Another feature of importance is the fact that the shell or bowl is removable. By having two shells, one can be used for ferrous and one for non-ferrous metals; or one can be relined or the lining patched while the other is in use.

Repel-Arc furnaces are made in the following standard sizes for 22-volt, three-phase operation: ⅛, ¼, ½, 1 and 1½ ton capacity. On account of the ability to make use of both the direct and indirect system, all furnaces are adapted to the melting of all metals which can be successfully handled in an electric arc furnace, such as steel, iron, copper, brass, nickel, aluminum, Monel metal and the many alloys used in the various industries.

An Improved Scleroscope

As IS well known, in hardness testing the surface resistance of metals must be overcome as by application of a given force on a spherical point. This operation leaves permanent indentations of a size varying in proportion to the material's resisting power or hardness.

The older way had been to measure the indentation under a microscope or depth gage, then to convert into suitable hardness degrees. This method, however, is not practical on hardened steel, and otherwise it is so uncertain and painstaking as to render it almost unavailable for regular commercial use.

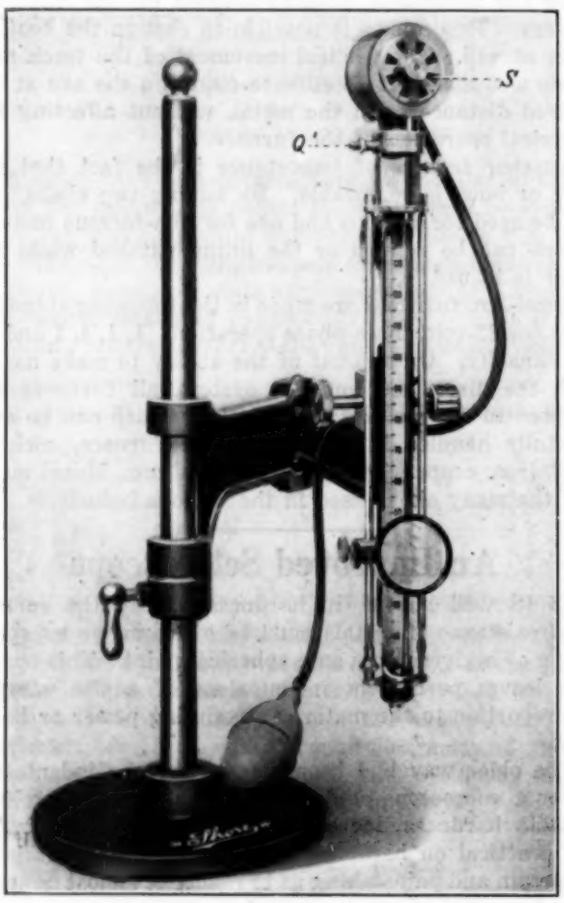
The Shore direct reading principle, embodied in the scleroscope, is more convenient and is applicable to not only soft metals but the hardest steels as well. To this end is utilized a diamond-tipped hammer, which, after falling, indents the metal microscopically and then rebounds to a graduated height which is in exact inverse proportion to the size of the said indentation. Notwithstanding the great speed at which this instrument may thus be operated, full accuracy is maintained. Comparatively little or no nervous fatigue is involved, hence it has best met all requirements of economical and commercial hardness measuring.

In view of this fact, that the scleroscope has met with universal approval and adoption is perhaps needless to mention. The demands made on it recently, however, have been so intensive and often under such adver-

conditions that its manufacturer, the Shore Instrument & Manufacturing Co., has made a closer study of the advanced conditions of its application, with a view to improving it further. The results were very satisfactory and it is announced that the scleroscope formerly known as Model C has, by virtue of modifications, been listed as Model C-1. The refinements made so increase the flexibility of the operating mechanism that it will give more uniform service even though the adjustments are comparatively approximate and the working conditions, including the skill of the operator, are less favorable.

Features of the New Scleroscope

Among the features are: (1) special fine screen *S*, for eliminating dust from the operating mechanism; (2) the leather operating piston formerly used has been replaced by one of tungsten steel, which is practically



IMPROVED SCLEROSCOPE

indestructible; (3) the former rigid adjustments of the hammer-hook mechanism have been replaced by a flexible adjustment *Q* which also greatly prolongs the life of the glass tube: (4) the hammer hooks have been provided with shock shoulders, which eliminate breakage of disalignment of these parts. In addition, more highly perfected glass tubing is being employed.

Altogether, the refinements that have been added to the Improved Scleroscope Model C-1 have greatly increased the ease of operation under all conditions and speeds. This advantage will be appreciated by the painstaking laboratory man, as well as by the modern precision manufacturer, whose problem is one of quantity production.

Synopsis of Recent Chemical & Metallurgical Literature

Combined Iron and Steel.—Dr. Percy Longmuir read a paper on this subject before the Birmingham (England) Metallurgical Society, and is reported by *The Iron and Coal Trade Review*, Oct. 28, 1921, p. 617, to have said that composite articles of iron and steel had been made in Sheffield for 50 years. They are particularly useful for cutters operating at high speed on organic fibers (wood, paper, grass, wool), withstanding vibration and sudden impact better than all-steel tools. A steel cutting surface backed with tough iron may be hardened to equal hardness over its entire face, and needs only regrinding for sharpening, whereas a solid steel blade would break under work if hardened throughout. The former will bend under a shock which would shatter the latter.

Welding soft iron to hard steel is beyond the smith's skill, even though some of them can weld high-carbon metal when making "double shear" steel. It has often been proposed (and done) to pour molten steel about hot wrought-iron bars, or thrust them into the mold after pouring. After rolling, the wrought iron is found to have preserved its identity, but shows the characteristics of "burnt" metal—i.e., "tenderness" and brittleness.

A more successful method consists in using a mold with a vertical partition, filling one half with crucible steel, and almost instantly the partition is removed as the remainder of the mold is filled with molten iron. On cooling, the composite ingot is found to be securely welded; it is dressed, cogged into a bar, and rolled into plates, ready for annealing, forming into tools, and hardening. Excessive piping was very rare in ingots which had been properly welded, and the latter was purely a matter of good workmanship. The raw materials were of best stock and crucible melted, and treated according to tool steel practice. Although high-speed steel and other complex alloys have been used, the ordinary materials are as follows:

	C	Si	Mn	S	P	Brinell
Low-carbon iron...	0.08 to 0.15	0.05	0.30	0.035	0.035	120
Steel	0.75 to 1.40	0.10	0.30	0.03	0.03	

A knife made from the combined iron and steel gave a Brinell hardness on the steel face of from 600 to 627 at distances ranging from 1 to 4 in. from the cutting edge. A solid steel knife of the same shape and for the same purpose had a Brinell hardness of 512 1 in. from the edge, 444 at 2 in., 228 at 3 in. and 207 at 4 in.

Stainless Iron.—We have already published a note[1] to the effect that stainless iron has been marketed in England for automobile bodies. Dr. Leslie Aitchison has now read a paper before the British Institution of Automobile Engineers (November, 1921, meeting) on "Chromium Steels and Irons." He noted that freedom from corrosion is definitely an attribute of chromium; 25 per cent of nickel not being the equal to one-half that amount of Cr in this respect. It is not well appreciated that the properties of the steels are profoundly affected by carbon; too high carbon may accelerate corrosion, but on the other hand carbon as low as 0.07 gives easily forged metal little subject to surface defects. It is thus very useful for sheet, strip or intricate drop forgings, even if weaker than stainless "steel" (C 0.40±). Its price, too, is lower. The effect of carbon can easily be seen by comparing steels containing approximately 0.20 Si, 0.20 Mn, 12.00 Cr, 0.50 Ni:

	Maximum Stress After Quenching and Drawing at—			
Carbon Content	500° C.	600° C.	700° C.	750° C.
0.07	144,800	98,200	80,800	73,400
0.15	179,000	112,800	93,600	87,800
0.37	210,000	128,200	108,000	.....
1.01	.....	.....	88,800	73,600

A lower chromium steel (C 0.11, Cr 4.72) has strength slightly less than the first one given above, but rusts fairly easily.

[1] CHEM. & MET. ENG., Oct. 12, 1921, p. 717.

Current Events
in the Chemical and Metallurgical Industries

Fails to Produce Gasoline From Peat in Court

In the course of the civil action alleging fraud (see CHEM. & MET. ENG., vol. 24, p. 985; June 1, 1921) which William H. Doolittle, of Woodmere, L. I., brought against Louis E. Enricht, president of the Enricht Peat Gasoline Co., Inc., the inventor was given an opportunity to demonstrate his process in the Nassau County Court before Judge Lewis J. Smith.

On Dec. 8 Charles Krainzler, of Farmingdale, testified that he had been secretary of the company until convinced that it was not a legitimate enterprise. He then resigned. (See CHEM. & MET. ENG., vol. 24, p. 506, March 23, 1921.) He also testified that the gasoline which was apparently produced from the peat really came from a secret receptacle in the apparatus which was filled prior to the demonstration. Accordingly, previous to the court demonstration on Dec. 9, the entire apparatus was taken apart and carefully inspected by three chemical experts, Dr. William B. Stoddard, Dr. Irving Hochstadter and F. J. Kenny. Difficulty was experienced in attempting to take apart the suction-pressure pump and a recess was granted to enable Mr. Enricht, accompained by the experts and both attorneys, to take the pump to a garage and open it.

Before the apparatus was assembled, Dr. Stoddard explained to the jury the function of each part as he understood it from his inspection and from the inventor's diagrams, never having seen the apparatus in operation. The equipment differed somewhat from that described on page 214 of the Feb. 2, 1921, issue of CHEM. & MET. ENG. In the first place, there was no mention of methanol, the only product being gasoline. A bicycle pump served to force air through a copper coil inclosed in a brass case and then through the combustion chamber in which the peat was to be burned. This was connected to a catalyst chamber containing staggered baffle plates supporting the catalyst. A three-compartment trough for water formed the bottom of the chamber. Next came a sort of gas holder formed of a capped brass pipe fitting closely inside a piece of iron pipe. A second catalyzer chamber followed. The gases could be drawn through all this apparatus by the suction side of the double-acting pump referred to above, and forced under pressure through the remaining parts, which consisted of a soldered brass can and a small receiving tank.

About 2 o'clock Mr. Enricht began to assemble the apparatus under the close scrutiny of the experts and the jury. Innumerable small bolts had to be put in place and tightened, so that it was 5 o'clock before the inventor announced that everything was in readiness for the test.

After filling the base of the first catalyzer with water, peat was placed in the combustion chamber and ignited. Vigorous operation of the bicycle pump soon filled the court room with smoke. The heavy suction-pressure pump was then manned by a court attendant. Smoke continued to pour out, the pumps wheezed and the court attendants were relieved as they became fatigued. After several minutes, Mr. Enricht gave up the experiment, explaining, however, that the apparatus was not air tight after having been re-assembled and that consequently he could not maintain the required pressure. In answer to a question by the judge, he admitted that the demonstration was over. His attorney attempted to arrange for a further demonstration after the apparatus had been made air tight, but the judge refused permission.

On the witness stand, Mr. Enricht admitted that his name had been Henricht in Germany and that he had been fined $500 in the federal court in Chicago in 1902 for using the mails for fraudulent purposes in connection with a land deal. In answer to one question he insisted that he never claimed to make gasoline, but that his product was naphtha or rather hexane, C_6H_{14}. He also admitted that in spite of the protest of the plaintiff's lawyer, he had worked the suction-pressure pump vigorously while taking it to the garage, that he had removed what appeared to be gelatine from the barrel of the pump after it had been opened in the garage and that naphtha was found in one of the rubber tubes connected to the pump. He stated that this naphtha must have remained in the pump since the last demonstration, although this was made about 2 months ago.

A copy of a citation from the United States Patent Office in regard to an application for patent filed Sept. 25, 1920, was also introduced into the record. All claims were rejected because the process was clearly inoperative and contrary to the now known laws of physics and chemistry. For further consideration the affidavits of several impartial witnesses would be required. It was suggested that the Bureau of Standards or the Bureau of Mines might be willing to test the process, if requested. The need for having two separate catalyst chambers with merely a gas holder between was questioned, as well as the reason for using such a high pressure, since the supposed product, C_6H_{14}, is a liquid under normal conditions.

The trial was still on as this magazine went to press.

German Potash Syndicate Captures American Market

At a meeting of the New York Section of the American Chemical Society Friday evening, Dec. 9, Dr. John E. Teeple, chairman of the section, announced that according to a copy of a contract in his possession, thirty-four American users and distributers of potash for agricultural purposes have entered into an agreement whereby at least 75 per cent of the requirements of the group for the period from June 1, 1921, to April 30, 1922, shall be purchased from the Deutsches Kalisyndikat.

As set forth in the copy of the contract, the total of the minimum purchases on a 75 per cent basis for all thirty-four companies is only 35,680 short tons of K_2O, a figure well within the productive capacity of the American potash plants. Yet it is understood that the American firms were not given a fair opportunity to bid, although they expressed willingness to meet foreign prices.

Dye Investigation Ordered

The United States Senate has authorized its Committee on the Judiciary to investigate "the charge that the dye industry is controlled by a combination of corporations which is in fact a monopoly and has employed agents, attorneys and lobbyists to influence Congress in behalf of special legislation to the interest of such monopoly, and to investigate the activities and methods of importers of dyes from Germany and their agents, attorneys and lobbyists to influence Congress in behalf of special legislation and to investigate the dye and chemical industries of the United States and the supply and distribution methods within the United States and elsewhere of the German dye and chemical industries with a view to recommending proper legislation."

That portion of the resolution which refers to the investigation of the practices of importers was an amendment to the original resolution proffered by Senator Frelinghuysen.

During the consideration of the amendment, Senator Frelinghuysen made an extended speech in which he stated that ample reason did not exist for any such investigation and that the purpose behind it is entirely unfriendly to the great American industry. In his address, Senator Frelinghuysen had suggested that the Department of Commerce, with its commodity specialists, is better equipped to conduct the investigation than is the Committee on the Judiciary.

The sub-committee which will conduct the investigation had not been appointed at the time of this writing.

More Plants Increasing Operations

Rubber. The Excell Rubber Co., Wadsworth, Ohio, has resumed operations, following a shut-down for a number of weeks. The company has been reorganized.

The Ajax Rubber Co., Trenton, N. J., has resumed production at its plant, following a shut-down due to a strike of operatives. A settlement has been reached and about 1,000 men have returned. The mill will operate on a full-time, or three-shift, basis for the manufacture of automobile tires.

The Millville Rubber Co., Millville, Mass., a division of the United States Rubber Co., specializing in footwear products, has increased its working force for a night-shift operating schedule.

The B. F. Goodrich Co., Akron, Ohio, is increasing production in its automobile tire department approximately 1,200 tires a day, making a total output of close to 10,000 tires daily at the present time. About 500 employees have been added to the working force in different departments.

Ceramic. The Homer Laughlin China Co., Newell, W. Va., and East Liverpool, Ohio, is operating at capacity and close to normal.

The Warwick China Co., Wheeling, W. Va., has placed its plant on a full-time production basis.

Crane & Co., Chicago, Ill., have placed their recently acquired plant of the Mutual Enamelware Co., Chattanooga, Tenn., on a production basis. The name has been changed to the Crane Enamelware Co.

The American Bisque & Novelty Pottery Co., Williamstown, W. Va., is operating at capacity, and plans for plant extensions for greater output.

The Robinson Clay Products Co., Akron, Ohio, has developed greater production at its plant, and plans to maintain operations at a comparatively high rate throughout the winter period.

The Edwin M. Knowles China Co., East Liverpool, Ohio, with other plants at Chester and Newell, W. Va., has adopted a normal working schedule at all plants.

The Carr China Co., Grafton, W. Va., has increased production at its plant.

The Chelsea China Co., New Cumberland, W. Va., has advanced operations at its plant to a point close to normal.

Iron and Steel. The United States Cast Iron Pipe & Foundry Co., East Burlington, N. J., has increased production to a point of from 45 to 50 per cent of normal at its different foundries.

The East Penn Foundry Co., Macungie, Pa., manufacturer of brass, iron and other castings, is operating at full capacity, with good advance orders for future production.

The E. & G. Brooks Iron Co., Birdsboro, Pa., has placed its local sintering plant on a double operating shift. The plant was destroyed by fire some time ago and has been completely rebuilt, with installation of new machinery.

The Wickwire-Spencer Steel Co., Buffalo, N. Y., has increased operations at its local finishing mill to a point of about 75 per cent of normal. One blast furnace is in operation. Production is being increased at the New England mills of the company.

The Carnegie Steel Co., Steubenville, Ohio, has placed its local plant on a 60 per cent capacity basis.

The Gulf States Steel Co., Gadsden, Ala., is said to be planning to blow in its local blast furnace early in January.

The Fabricated Steel Co., Leetonia, Ohio, has resumed operations after a curtailment of a considerable period.

Miscellaneous. The American Cellulose & Chemical Mfg. Co., Amcello, near Cumberland, Md., has commenced production at its new local plant for the manufacture of celluloid, artificial silk, etc., and daily shipments of material will be made. A gradual increase will be made in the working force as conditions warrant.

Industrial Plants in Georgia Expand

The Georgia Manufacturers' Association, Atlanta, reports that industrial conditions are better in the state than at any time for the past year. A recent canvass shows that 55 per cent of manufacturing plants are operating at full capacity; 35 per cent under a part-time schedule; and about 10 per cent of state plants are idle.

First Report of Federal Power Commission

Judging from the applications which followed the passage of the federal water-power act of 1920, the Federal Power Commission concludes in its first annual report that the production and use of hydro-electric power in the United States will be the outstanding industrial fact of the next 25 years. In 16 months, following the passage of the act, there were filed with the commission 185 applications for preliminary permit and 85 applications for license to develop water power, aggregating 11,060,000 primary and 5,766,000 secondary horsepower. To complete these projects would mean a capital expenditure exceeding in the aggregate two billion dollars. The following table shows the geographical distribution of applications:

DISTRIBUTION OF APPLICATIONS BY STATES

	No. of Applications	Horsepower — Primary (90 per Cent of Time)	Horsepower — Estimated Installed Capacity
Alaska	31	217,200	279,060
Alabama	4	35,025	147,000
Arizona	13	3,544,160	4,750,000
Arkansas	4	94,100	169,000
California	80	2,118,810	4,057,075
Colorado	4	50,660	100,900
Connecticut	2	20,000	32,000
District of Columbia	1	47,300	50,000
Florida	4	6,540	12,100
Idaho	12	90,650	189,185
Illinois	1	41,450	50,000
Kentucky	1	96,000	160,000
Louisiana	1	40,000	55,000
Minnesota	7	38,150	79,300
Mississippi	1	.....	.....
Missouri	4	8,000	55,000
Montana	14	319,875	532,450
Nevada	1	(Transmission Line)	
New Jersey	3	361,400	432,300
New Mexico	1	2,750	25,000
New York	16	1,712,845	2,192,830
North Carolina	3	3,160	16,400
Ohio	2	210	250
Oklahoma	3	34,880	54,000
Oregon	10	466,060	832,860
Pennsylvania	1	38,400	80,000
South Carolina	2	2,000	8,000
South Dakota	1	(Transmission Line)	
Utah	6	918,015	1,212,465
Virginia	2	29,760	110,000
Washington	18	699,930	1,112,640
West Virginia	2	11,200	20,000
Wisconsin	1	10,000	20,000
Wyoming	4	1,410	1,410
Total	260	11 059,910	16,826,225

Up to Nov. 1 final action has been taken on 59 applications, in which 27 preliminary permits and 31 licenses were authorized, involving 1,415,600 primary and 2,627,000 installed horsepower. Of the projects under license construction is now under way on the following:

	Primary	Installed Hp.
Henry Ford & Son, Inc., Hudson River, N. Y.	3,640	6,100
Niagara Falls Power Co., Niagara River, N. Y.	341,500	572,230
Southern California Edison Co., Big Creek, Cal.	165,000	545000
Alabama Power Co., Coosa River, Ala.	21,760	110,000
Snow Mountain Power & Water Co., Eel River, Cal.	9,500	16,670
Western States Gas & Elec. Co., American River, Cal.	6,400	6,400
Wisconsin-Minnesota Light & Power Co., Chippewa River, Wis. (Preliminary construction only)	10,000	20,000
Total	557,800	1,276,400

The commission finds itself handicapped in passing on many engineering and economic problems due to a ruling of the Comptroller of the Treasury that the commission is not empowered to employ persons other than its executive secretary. This makes it necessary to rely upon assignments or detail of individuals from other executive departments of the government, which is a very unsatisfactory method of administration. The commission feels that the law should be amended to permit it to employ the proper engineering personnel.

Civil Service Examinations

Vacancies in the Chemical Warfare Service, Edgewood Arsenal, Edgewood, Md., will be filled from the following examinations:

Chemist, $3,600 to $5,000 a year; associate chemist, $2,500 to $3,600; assistant chemist, $1,800 to $2,500. Applications for these positions will be received on Form 2118 until Jan. 10, 1922. Chemical laboratorian, $1,200 to $1,500; examination will be held Jan. 11, 1922.

Practical Use of Helium Demonstrated

"The practical use of helium as a gas for the inflation of airships has been demonstrated beyond a doubt." This statement was authorized by the Navy Department after the successful flight of the C-7 from Hampton Roads to Washington and return. The men in charge of the trip declare that the ship maneuvered very much better than when inflated with hydrogen and since the gas does not expand and contract as rapidly as hydrogen, it makes for economical operation. During the entire time that the C-7 was inflated, there was no helium lost by valving. The most striking deduction from the trip, however, is that, heat conductivity of helium being less than hydrogen, it practically eliminates the variation in the lifting power of different portions of the bag. This is of the greatest value

THE FIRST HELIUM-FILLED AIRSHIP

in maneuvering. In addition, helium in twice as heavy as hydrogen, and therefore the bag possesses twice the stability as when inflated with hydrogen. Much greater speed can be attained with a helium-filled ship. An extract from the Navy Department's statement issued in connection with the flight is as follows:

"Helium, next to hydrogen, is the lightest gas known. It has 92 per cent of the lifting power of hydrogen and for military purposes possesses an inestimable advantage over hydrogen in that it is non-flammable. The natural gas wells in the United States afford a practical monopoly of the known sources of supply. According to the latest estimates, helium is escaping into the atmosphere at the rate of 1,250,000 cu.ft. a day, or at a rate sufficient to fill four large airships a week. The refrigeration process is employed to obtain helium. In this process every constituent present in the natural gas is liquefied except helium, which is expelled into suitable containers for storage. The application of this process to the extraction of helium has not been perfected, but the line of development is reasonably clear."

Dr. Joseph S. Ames, chairman of the National Advisory Committee for Aëronautics, is recommending that the government acquire and seal for future use the best helium-producing gas fields; that experiments must be continued in the development of an efficient and economical process for the extraction of helium. He states that with large reserves of helium and the development of types of airships to realize fully the advantages in the use of helium, America would possess resources with which no other nation could compete.

Extra Zone Postage on Chem. & Met. Canceled

The extra zone postage west of the Mississippi River, which has been charged for some time past on CHEMICAL & METTALLURGICAL ENGINEERING and other McGraw-Hill papers, has been canceled by action of the company. There has been no change in the rates of postage charged by the government, but the owners of CHEMICAL & METALLURGICAL ENGINEERING felt that by absorbing this extra cost they could remove a frequent complaint of discrimination against Western subscribers. Extra postage heretofore charged to Canada, Alaska, Hawaii, Philippines, Porto Rico, Canal Zone, Cuba, Mexico, Honduras, Nicaragua, Dominican Republic, Salvador, Peru, Colombia, Bolivia and Shanghai, China, has also been canceled.

Annual Report of the Secretary of Commerce

Herbert Hoover has transmitted to the President the ninth annual report of the Secretary of Commerce, covering the fiscal year 1920-1921. On assuming office March 4, 1921, the Secretary gave attention first to reorganization of departmental expenditures and second to the reorganization of bureaus in his department directly concerned with industry and trade, in order that they might give better service. The reorganization of departmental expenditures has enabled the department to revise its estimates of expenditures for the fiscal year 1921-1922 with a net saving of about four million dollars, or 16⅔ per cent of the available appropriation.

The Secretary calls attention again to the great need of a government-owned building for the department; of a national archives building of fireproof construction; and of a revision of the increase of per diem allowance for traveling expense from $5 to $7.

The Bureau of the Census, in addition to its regular duties, has been assigned the work of compiling statistics for a monthly report known as the Current Survey of Business, to show the trends of business and industry throughout the country. This monthly report has already proved useful to the business public and plans are under way for its improvement. Attention is called to the possibility of assigning to the Bureau of the Census investigations of other government bureaus, such as the Geological Survey, Bureau of Mines, etc. This suggestion is made in the interest of avoiding duplication of work.

The Bureau of Foreign and Domestic Commerce has improved its foreign service through commercial attachés and trade commissioners. Membership changes in personnel have been made in the interest of more efficient work. The report gives in considerable detail the work of the bureaus' representatives in different parts of the world, with typical examples of the practical value of this service. Monthly cable service is published in *Commerce Reports*, comprising strictly up-to-date information from the bureau's representatives throughout the world. *Commerce Reports* has been revised in size and make-up, much to the advantage of both the bureau and the readers. The practice of grouping various articles under commodity headings is an improvement of considerable value.

The work of the Bureau of Standards has been devoted to weights and measures, electrical standards, investigations in heat and pyrometry, optics, engineering physics, metallurgy, ceramics, and miscellaneous materials. The chemical division co-operates with all other divisions of the bureau, as well as with other departments of the government. Thus valuable assistance has been given to the Bureau of Engraving and Printing in connection with the production of engraved plates by electrolytic methods. The chemical division has also served the Air Service of the Army and Navy by testing balloon fabrics. It also rendered service to industry in general by preparing and distributing 4,016 standard samples of metals and alloys.

Federal Trade Commission Amends Complaint Against Steel Corporation

The complaint of the Federal Trade Commission against the United States Steel Corporation and its subsidiaries has been amended to make its charges more specific and to simplify the issue and expedite the hearings. The issue in the amended complaint is the same as that contained in the original complaint.

The original complaint charges the corporation and its subsidiaries with discriminating in price between the purchasers of all of its rolled steel products. The amended complaint makes precisely the same charges with respect to each particular rolled steel product. The amended complaint, as did the original, charges that such discriminations are in violation of the Clayton and federal trade acts for the reason that they are not made because of any difference in the grade, quality or quantity of the product sold, nor because of different cost of selling or transportation, nor because the different prices were made in good faith to meet competition.

Additional Commodity Divisions, Department of Commerce

In view of the propitious start made by the commodity divisions of the Department of Commerce, the President and the director of the budget have approved a request for an appropriation of $540,000 for the continuance of the work in the interest of the export industries during the next fiscal year. This is an increase of $290,000 over the amount appropriated for this work during the current fiscal year. It is proposed to set up seventeen additional commodity divisions, as follows: vegetable oils and breadstuffs; meat and dairy products; canned goods; cotton and cotton goods; wool and woolen goods; petroleum; dyes and drugs; heavy chemicals; paints, varnishes and tanning materials; hardware and tools; glass and earthenware; paper; nonferrous metals; transportation and communication; foreign investments; advertising, packing and credit methods; maps and commercial geography. The existing commodity divisions are: iron and steel; lumber; shoes; rubber goods; heavy machinery; implements and vehicles; automobiles; electrical goods; foodstuffs; textiles; fuels; leather; office appliances; specialties. The iron and steel division is receiving an allotment of $17,000; the lumber division $14,000, the shoe division $12,500 and rubber goods division $14,000. The other existing divisions are each allotted $15,000 for their annual expenses. It is planned that each of the new divisions is to be allotted $15,000. It each case the chief of the division is to receive a salary of $6,000 and the assistant chief $2,000.

For the general work of promoting commerce, Congress is asked to appropriate $524,050, an increase of $199,050 over the appropriation for the current year. Under this appropriation it is proposed to establish new trade commissioner offices in Russia, in Greece and in Canada. It is also the plan to undertake special technical investigations in connection with iron and steel in England, Belgium, Germany and France; in connection with lumber, in the Scandinavian countries; in connection with electrical goods, in Germany, France and Belgium; in connection with fuels, in England, Belgium and Germany; in connection with leather, in Germany, Spain, Holland and Belgium. Similar investigations are to be undertaken covering office appliances and specialties.

In addition, $213,650 is asked to promote further the commerce between the United States and Latin America. This is an increase of $113,650 over the current year's appropriations. A portion of the increase is to be applied to the establishment of new trade commissioner offices in Cuba, Colombia, Uruguay and Venezuela. New technical investigations are to cover chemicals, hardware, tools, implements, glass and glassware and foodstuffs.

For promoting commerce in the Far East, $235,650 is asked. This is an increase of $85,650. It is proposed to establish under that appropriation new trade commissioner offices in Delhi, Bombay or Calcutta and in Canton. New technical investigations to be undertaken in the Far East would cover textiles, vegetable oils, silks, fibers and petroleum.

Chilean Nitrate Situation

Large nitrate sales in London have greatly encouraged the Chilean producers, according to advices reaching the Department of Commerce. The agreement reached between the Nitrate Producers' Association and the Nitrate Pool, of London, caused a decided rise in the exchange value of the Chilean peso. A part of this gain was lost because of the report that the agreement provided for a material reduction of existing stocks in Europe before further exports were to be attempted. The recent brisk demand for nitrate, however, promises to consume the European stocks in a shorter time than had been expected.

The consul at Iquique reports September nitrate production to have been 1,493,229 quintals. In September of 1920 the production was 4,501,850 quintals. The present rate of production is practically double the rate of exportation, with the result that stocks in Chile are increasing rapidly. The consul states that 29,000,000 quintals has been estimated as the probable 1921 production. The 1920 production of nitrate was 55,514,000 quintals.

Dental Amalgams

No organization not primarily devoted to dental interests ever met in the Dental Dispensary at Rochester until Monday evening, Dec. 5, when the local branch of the American Chemical Society assembled there to hear an address on "Dental Amalgams" by Dr. Arthur W. Gray of Milford, Del.

Dr. Harvey J. Burkhardt, director of the dispensary, gave a short talk concerning the work he and his associates are doing in preventive dentistry, starting first with the children in the schools.

Dr. Gray, in his address, said that dental amalgams are made by the dentist when he mixes dental alloy and mercury before putting the mixture in the cavity to be filled. Some of the best amalgams when hardened have the strength of steel. The older amalgams were not nearly so good and frequently broke.

A dental alloy is made of silver and tin containing from 40 to 70 per cent of silver. Small amounts of other metals such as copper, zinc and gold or platinum are sometimes used. The metals are weighed, then melted and cast into ingots. Any iron that may be present is then removed and the alloy is annealed.

The dentist mixes the alloy with mercury, any excess of which should be expressed. As amalgam is packed into the cavity still more of the mercury is pressed out. The polishing should not be done the same day because of changes taking place in the amalgam. After the alloy is in the tooth it hardens rapidly at first and then more slowly for a week or 10 days. Sometimes it will contract so much as to leave a crevice around the filling, or it may expand so as to crack the teeth.

Alloys of a lower silver content are easy to amalgamate, but they will crush. The alloys of high silver content are much harder to work; they retain much more mercury and are far more lasting. Low-silver alloys were used up to 1895 and unfortunately some are still used because they are easier to handle and cheaper.

The first well-organized and comprehensive work on dental alloys was done by Dr. G. V. Black, a dentist with a medical education, and an old-time scientist. This work was carried on from 1895 to 1897. If an alloy is cut up into shavings it will continue to change for months and even years. It becomes easier to work and expands less. Dr. Black thought this aging was due to oxidation, but later decided it was due to temperature, the higher the temperature the faster the aging. He organized a class of manufacturers and taught them how to make alloys and how to anneal them so there would be no changes. In 1905 Dr. Ward through many experiments showed the necessity for controlling the temperature while annealing.

Dr. Gray is convinced that the contraction of the amalgam is due to the formation of a silver mercury compound when the silver-tin alloy is mixed with mercury. Later this crystallizes and there is an expansion. By extensive experiments Dr. Gray has found out the effects upon contraction and expansion by using different temperatures, different pressures and length of time for trituration. These were made very clear by graphs used with the lantern slides. Following the lecture Dr. Gray showed samples of alloys.

Illinois Short Course in Ceramic Engineering

The regular biennial two weeks short course in ceramic engineering will be given next January at the University of Illinois, between Jan. 23 and Feb. 4. The subjects covered will include elementary physics and chemistry; the origin, classification, winning and refining, and testing of clays; the shaping, drying and burning of clay products; bodies and glazes; the technology of glass; refractories and refractory products; kiln construction; coal and gas fuels; engines and boilers, dynamos and motors, equipment control; pyrometry; drafting and reading of drawings; and business law.

The complete program will be ready for distribution early in January and copies may be obtained by addressing the Department of Ceramic Engineering, University of Illinois, Urbana, Ill. The course is open to all who are interested and can be taken to advantage by any one having a common school education. There are no tuition fees.

Institute of Baking Is Opened in Chicago

The American Institute of Baking, behind which is the American Bakers' Association, has recently transferred its activities from Minneapolis and become established at 1135 Fullerton Ave., Chicago. The institute has absorbed the Wahl-Henius Institute, together with the property at the above location. The history of the Wahl-Henius Institute begins 35 years ago with the establishment of a crude analytical laboratory operated by Dr. Max Henius and Robert Wahl, two analytical and consulting chemists. The institute operated for many years in the study of scientific brewing; and with the new change will come the working over of the plant to serve the bread-baking industry.

Mechanically speaking, there is little difference in the processes of analyzing and experimenting in bread and beer, so with comparatively few changes the building has become a workshop of the baking industry, with an experimental brewery turned into a practical bakery plant.

The institute has four large laboratories and a special laboratory for students; class rooms, lecture rooms, scientific library, auditorium and many other facilities. Dr. H. B. Bernard has moved from Minneapolis to Chicago to become head of the combined organization. Under his direction the institute is to put the baking industry under higher technical control by producing scientific bakers.

Report of the Chemist, Department of Agriculture

In his report of July 1, 1921, as chief of the Bureau of Chemistry, Department of Agriculture, Dr. C. L. Alsberg reviews the work of the various laboratories under his direction. The work of the bureau is of two kinds: Scientific research and enforcement of the food and drugs act. In the realm of scientific research the bureau has established a number of laboratories devoted to special purposes. The report concerns itself in detail with the work of these various laboratories and must be consulted for a comprehensive idea of their investigations. The names of the various laboratories, suggestive of their scope, are as follows: Water and beverage; microchemical; microbiological; cattle food and grain investigation; pharmacognozy; drug division; pharmacological; carbohydrate; oil, fat and wax; citrus byproducts; food research; dehydration; protein investigation; phytochemical; leather and paper; insecticide and fungicide; and color investigation.

One of the most important parts of the bureau's work has been conducted in office of development, which was established in 1920. It has engaged in various activities looking toward the commercial development of discoveries of the bureau's staff, with a view to creating an industrial outlet for agricultural products. The office of development work has also made some excellent investigations of grain-dust explosions and fires.

Proper Functions of Trade Associations to Be Defined

What functions and activities trade associations may legally engage in will soon be announced by the government E. W. McCullough, manager of the fabricated production department of the Chamber of Commerce of the United States, told the American Face Brick Association in annual convention Dec. 2 at White Sulphur Springs, W. Va. He said that such a statement would have been issued before this but for the fact that several government cases are now pending against certain trade associations, involving such questions as the proper use of statistics, open price plans and averages in cost accounting.

According to Mr. McCullough, Secretary Hoover desires closer contact with the industries through their associations, but Secretary Hoover has intimated that such organizations should put themselves in position to speak for their industries by including in their membership the largest possible representation, and also through the perfection of their machinery for gathering, analyzing and compiling all desirable information of service not only to themselves but to the government and the public as well.

It is to make for such co-operation that the government is expected to define the proper functions of a trade association, Mr. McCullough said.

Chemical Items in U. S. Budget

While the outstanding chemical appropriation in the federal budget is that of $1,500,000 for the Chemical Warfare Service, there are chemical activities in practically every executive department and in some of the independent agencies. In many cases the money for chemical activities is not segregated. Those which are segregated are as follows:

Bureau of Chemistry. For investigating chemical problems relating to the composition, action and application of insecticides and fungicides, $20,000; for collaborating with other departments desiring chemical investigations, $14,000; for investigations relating to the application of chemistry to agriculture, $75,400; for the investigation of table sirup and sugar, $10,000; for the investigation of naval stores, $10,000; for the investigation of methods for the prevention of grain dust explosions, $25,000.

Bureau of Standards. To develop color standards with special reference to their industrial use in connection with dyestuffs, inks and pigments, $10,000; to study methods of measurement and technical processes in the manufacture of clay products, $25,000; for the investigation of the problems involved in the production of optical glass, $25,000; for metallurgical research, $40,000; high-temperature investigation, $10,000; for the distribution of standard materials to be used in checking chemical analyses and in the testing of physical measuring apparatus, $10,000; for an investigation of radioactive substances, $10,000.

Bureau of Mines. For investigations concerning the utilization of heavy clay products, cement, feldspar and other non-metallics, $35,000; for work at mining experiment stations (a part of which is of a chemical nature), $175,000.

Geological Survey. For chemical and physical researches including researches with a view of determining geological conditions favorable to the presence of potash, $40,000.

In connection with the budget, the navy announces its salary scale for technical service. It is as follows: Chief chemist, $11.36 per day; chemist, $10.56, $10.24, $9.84, $9.44, $9.04, $8.72, $8.32, $7.92, $7.60, $7.20 per day; assistant chemist, $6.88, $6.40, $6.08, $5.68, $5.36, $4.88 per day; chief metallurgist, $3,000 per annum; assistant chief metallurgist, $8.32 per day; chemical engineer, $9.44 per day; laboratorians (chemical), $5.36, $4.56; superintendent, acid plant, $9.04 per day.

Secretary Weeks Favors Gas Development

In view of what is being said to be taking place in the executive sessions of the Conference on Limitation of Armament, particular significance is attached to the position taken by the Secretary of War in the report which he submitted to Congress on Dec. 8. In that report he made the following reference to chemical warfare:

> In reviewing our chemical production, it is apparent that the World War brought a new industry into the field of war production and therefore into close relation with the problem of preparedness for national defense. The preponderantly commercial character of this industry, the necessary progress of which as an element in our industrial system carries with a corresponding efficiency in its application to war purposes, conveys the practical assurance that we shall not prove deficient in the production of war chemicals. At the same time, the close relationship between the production of chemicals for war and the preparation of chemical products for peaceful industry compels a realization of the great benefits to our commercial chemical progress resulting from the activities of the War Department in respect to chemical warfare. Since our Chemical Warfare Service is well organized to keep abreast of our developments, there is every hope that we shall be adequately equipped in respect to chemical preparation for war. Though we may be opposed in principle to the use of poison gas, I am of the opinion that we cannot safely presume a similar attitude on the part of possible opponents and neglect the development of chemical weapons if we wish to insure a successful defense in a possible war. Therefore, since the development is of direct industrial benefit, and will not be wasted in any eventuality, I hope for the continued support of this activity by Congress and by the chemical industries themselves.

Arms Conference Action on Gas

No official confirmation or denial is forthcoming of the report that the American advisory committee has recommended that the use of gas in warfare be outlawed. It is known that very different opinions are held by a number of individual members of the advisory committee, although it is admitted that other influential members of that committee are actively seeking to write into any international agreement that may be reached a paragraph pledging the signatory powers to make no use of gas in warfare.

While Japan was expected to be most active in the effort to outlaw chemical warfare, no such activity has developed. Italy has been apparently the prime mover. The argument advanced by some of the Italians is that their country does not possess the raw materials for chemical munitions, and therefore would be put at a disadvantage if unrestricted use of gas were to be permitted.

Personal

DR. F. W. BOYER has been elected president of the Excell Rubber Co., Wadsworth, Ohio, succeeding Ross Trump.

WILLIAM A. DURGIN has been given a leave of absence from the Commonwealth Edison Co., Chicago, to direct the new activities of the Department of Commerce toward the elimination of waste in industry by simplifying and standardizing commercial practices. Mr. Durgin's new organization will form a subdivision of the Bureau of Standards.

RICHARD A. FEISS of Cleveland, Ohio, was elected president of the Taylor Society at its recent meeting in New York. Other officers were elected as follows: Vice-presidents, Horace K. Hathaway, Philadelphia, and Robert B. Wolf, New York; treasurer, Edward W. Clark, 3d, Philadelphia; managing director, Harlow S. Person, New York; directors, Ray M. Hudson, Peoria, Ill.; J. C. Heckmann, New York; Ida M. Tarbell, New York; Levi H. Ballou, Walpole, Mass.

H. J. ROLLS, Buffalo, N. Y., has been elected vice-president of the Buffalo Paint, Oil and Varnish Club, succeeding William P. Mott.

DR. EDGAR F. SMITH, president of the American Chemical Society, addressed the South Jersey Section at Carneys Point, N. J., Nov. 22. His subject was "The Early History of Chemistry in America." Officers of the local section elected for the ensuing year included Dr. C. E. Burke, chairman, and Dr. H. D. Gibbs, councilor.

HENRY A. TOBELMANN, metallurgist for the New Cornelia Copper Co., Ajo, Ariz., has resigned to accept a position in New York City. Mr. Tobelmann has been continuously in the service of the Calumet & Arizona Mining Co. since 1906, first at Bisbee, later at Douglas and finally at Ajo, where he had much to do with the development and operation of the hydrometallurgical process there used.

Obituary

BENJAMIN F. GREENE, manager for the Westmoreland Chemical Color Co., Philadelphia, Pa., at New York, died recently at the Long Island College Hospital at the age of forty-nine years.

ROBERT B. HAWLEY, president of the Cuban-American Sugar Co., New York, died at his home, 36 Gramercy Park, Nov. 27, aged seventy-two years. He founded the company of which he was head in 1900, and since that time had been a prominent figure in the industry.

GUSTAV LEVOR, a pioneer leather manufacturer, president of G. Levor & Co., with tannery at Gloversville, N. Y., died at New York City, Nov. 28, aged seventy-one years. The company of which he was head was established in 1875, developing into one of the largest industries in this section.

Current Market Reports

The Chemical and Allied Industrial Markets

NEW YORK, Dec. 12, 1921.

The chemical market during the past week could be described as fair in some quarters, while in others a falling off was noticeable. The general opinion of leading factors, however, is that an irregular market may be expected temporarily due to outside influences incidental to this period of the year. There is no doubt that a decided change for the better will take place early in the spring of 1922 and there is no lack of confidence regarding business conditions over next year. Large producers reported a good volume of business with their regular consuming trade for shipment over 1922. The probability of further reductions of freight rates might have had a tendency to unsettle prices and in some cases practically to cause the discontinuance of actual production. On the other hand, there is a great deal of consolation shown by the marked improvement in the steel trade. The increased activity in the oil industry has meant the speeding up of new construction and steel mills have been operating at increased capacity. Soap factories are running in normal shape, but textile mills have slowed down to a considerable extent. Glass manufacturers are reporting conditions very favorable, with furnaces working at the highest point of the year. Spot prices have shown a little more flexibility than they did during the past two weeks. Imported sulphide of soda is lower. Prussiate of soda is easier. Imported caustic potash is a trifle lower under a continuance of a quiet inquiry. Bleaching powder is holding quite firm and this also holds true of domestic soda ash. Export sales of solid caustic soda were recorded during the week to Japan and South American countries, but the volume was smaller than noted a week ago. There was a rumor that foreign producers of caustic soda fell down on deliveries to Italy, which allowed the placing of orders involving several thousand tons in the American market. Oxalic acid is holding well under recent quotations. It is understood among large dealers that an order embracing several thousand kegs of chlorate of potash has been placed in Mexico. Prices for this material have been very irregular on spot owing to the free supplies and the limited consuming channels. Although there was no change in spot prices on this commodity, there was a pronounced tendency to keep prices firm. Shipment prices for high test granular salammoniac were reduced and goods were offered in the late trading at lower prices c.i.f. New York.

CHEMICALS

Spot *bichromate of soda* is attracting only moderate attention and scattered sales are reported a 7¼@8c. per lb. In most instances the lower figure was easily available on firm business. The tone of the market was steady, with offerings of a more or less general nature. Manufacturers of *bicarbonate of soda* continue to name 2c. per lb. for barrels f.o.b. works. Kegs are held at ¼c. per lb. higher. Spot offerings are heard around the trade at $2.30@$3.35 per 100 lb. A fair inquiry was noted from regular consuming channels, but there was very little additional business recorded. Trade conditions in *caustic potash* have remained quiet and the tone of the market appeared somewhat easier. Sales of imported material were recorded at 5⅝c. per lb. for the 88-92 per cent grade. The general quotation ranges from 5⅝@5¾c. per lb., according to quantity. Shipment material is obtainable at $5.30@$5.40 per 100 lb. c.i.f. New York. Dealers of *nitrite of soda* quote the market at 6¾c. per lb. and state that small sales are about the only feature of the market. It is quite possible that on a round lot a slight concession might be granted. Imported *prussiate of soda* is quoted a trifle lower on spot and the demand was not as brisk as noted a week ago. Small lots of this material are around the market at 14½@14¾c. per lb. Shipment prices are holding firm at 14½c. per lb. It is very doubt-

ful if better than this figure could be done on any future arrivals. *Muriate of potash* is also quoted a trifle easier at $35 per ton, basis 80 per cent. It is understood that some business has been placed a shade under this figure when round lots were concerned. The market has not shown any real signs of activity on this commodity for the past month and keen competition has driven prices down to a new low level. Leading producers of *copper sulphate* have advanced their prices. The carload price for standard 99 per cent, large crystals, is $5.65 per 100 lb. Smaller quantities are held at 5¾c. per lb. and upward, depending upon the size of order. The advance is believed due primarily to the upward tendency of the copper metal. The domestic demand was rather slow during the month of November. The foreign demand, however, has noticeably increased and American sulphate producers have been able to withstand the competition of foreign interests in Italy and other important centers. Prices for imported white granular *salammoniac* were reduced during the week and the market was established at 5¼c. per lb. for shipment, c.i.f. New York. This is the lowest figure recorded since the war. Domestic producers quote 7c. per lb., f.o.b. works. Prices for light *soda ash* in single bags on spot are being well maintained at $2.10 per 100 lb. for domestic goods. Some small lot sales have gone through at $2.15. Brokers around the city are quoting the imported material at $1.75 per 100 lb. ex-dock New York. Ash in barrels is held at $2.30@$2.40. Leading producers report a fair inquiry for forward shipments and state that sales over next year have been made at $1.40@$1.45 per 100 lb., in single bags and $1.60 in barrels, basis 48 per cent, f.o.b. works. Sales of spot *arsenic* have been recorded at 6c per lb. The demand is irregular, although business in general has shown some improvement. Shipment material is somewhat firmer with sellers naming 5¼c. per lb. Second hands offer solid *caustic soda* at $3.90@$4 per 100 lb. An additional call was noted from South America and the Orient and new business has been placed with these countries. Producers seem to be experiencing a good demand from their consuming trades and state that satisfactory business has been placed for delivery over 1922. Large contracts have been closed at $2.75 per 100 lb., basis 60 per cent, f.o.b. works.

The general quotation for moderate quantities on contract is $2.90 per 100 lb. basis 60 per cent, works. Buyers of *cream of tartar* are taking the imported material in moderate quantities at prices ranging from 25@26c. per lb. The market has shown a fair degree of activity since prices have been lowered and quotations held firm in the late trading. Prominent sellers of *oxalic acid* quote the market at 15c. per lb., spot New York. Odd lots were sold down to 14¼c. per lb. The demand continues quite active.

Coal-Tar Products

The coal-tar products market during the past week has undergone very little change. First hands seem to be getting prices on many products under their own control. This fact has not brought about any stability or uniformity in market prices. Sales during the early part of the week were confined mostly to small lots, but the aggregate amount was quite satisfactory. Inventories are keeping many mills from buying regular requirements and buyers are not disposed to place any forward business until this annual function is out of the way. *Phenol* is in very good demand and *paranitraniline* seemed a little firmer at the close of the week. *H acid* is also a trifle steadier since low-priced goods have become scarcer. First hands in *benzene* are in complete control of the market with no resale goods procurable. Quotations range from 27@33c. per gal. for future delivery. Coke-oven operations have increased to a limited extent and are now about 40 per cent normal. The increased output has not been felt to any extent in the benzene market. Foreign inquiries for *phenol* are being recorded in good volume, but there have not been many sales, as prices demanded by the buyers are quite frequently well below the general market. The tone of the market remains very firm, with prime stocks held up to 15c. per lb. Government surplus stocks are quoted at 12c. per lb., while resale material around the city ranges from 10@10¼c. per lb.

The St. Louis Market

St. Louis, Dec. 9, 1921.

Business for the month of November showed an appreciable increase over previous months and it is not expected that the approach of the stocktaking period will cause a cessation in buying for this month, which is based on the fact that the majority of the manufacturers and dealers have consistently kept their stocks at a minimum. Just at the present time buyers are chiefly concerned in covering their requirements for next year by contract, but these are not being freely offered by the producers. Importations continue to be heavy, but the general trend of prices is firm.

Alkalis

The *alkali* market is somewhat dull. Only small quantities are moving at the prevailing price of $4 per 100 lb. for the solid in drums f.o.b. point of production. The flake is somewhat more active at 25c. advance over the solid, 76 per cent material. *Soda ash* is in nominal demand, with the same price of $3 per 100 lb. in barrels prevailing. There has been no change in *bicarbonate* or *sal soda*, the price remaining at $2.90 and $2.15 respectively and the market is very dull.

Chemicals, Drugs and Pharmaceuticals

Ammonia water, 26 deg., is in steady demand. The demand and inquiries for *sulphate ammonia*, *pure granular*, continues to be very good at this time. *Bismuth salts* are moving fairly well in spite of the fact that this is the off season and the keen competition. The *bromide* market is firm with a good volume of business being transacted. *Carbon bisulphide* has fallen off, as the demand from the grain storing trade has been satisfied. In our last letter we called attention to *creosotes* and *guaiacols* being seasonable articles, and factors now report that these commodities are moving very lively, indicating that there is a good demand from the consuming channels, and wholesalers should carry liberal stocks. *Glycerine* is in strong demand, with prices advancing to 15c. in drums. Users are now contracting for their requirements over next year, causing the advance. Business on *hydrogen peroxide* at the present moment is scattered. *Iodides* are moving very nicely with a firm market. Increase in demand for *lithium salts* is reported. The demand for *narcotics* is exceptionally good. The demand at the present for photographic materials is not important in volume. Last week producers advanced their prices on *acid salicylic* and *soda salicylate* and yesterday *acid acetyl salicylic* followed suit. Further uplifts would not prove surprising. *Sulphur commercial* is moving slowly at $2 per 100 lb. in 25-bag lots, with a slight advance for smaller quantities. There is practically no business in the special brands. *Zinc oxide* is in good demand and makers are very optimistic of the future, expecting an increased demand; the price remains at 7¼c. in barrels and 7¼c. in bags f.o.b. works for standard brands. There has been no dropping off of orders for *zinc stearate*. In fact, during the last period, an increase has been manifest.

Acids

The heavy commercial mineral acids are assuming a better position and moving in larger volumes. *Carbolic acid*, medicinal grade, continues to move through regular channels. *Acid acetic* is rather slow. *Gallic acid* and *tannic acid* are moving pretty well.

Vegetable Oils and Naval Stores

Castor oil is very firm, with the price of 12¼c. in barrels and 12c. in returnable drums still prevailing. *Linseed oil* is moving very low due to the dull season in the paint industry. *Turpentine* has advanced slightly, now selling at 84½ in single barrels with a 4c. differential on 5-bbl. lots.

Paint Materials

The dull season in the paint industries has had a very decided effect on the *barytes* market. The movement is practically nil, although the old price of $23.50 still holds. Manufacturers expect very little business until after Jan. 1. There has been no change in the *lithopone* market. *Whiting* is moving slowly at $15 per ton.

The Iron and Steel Market

PITTSBURGH, Dec. 9, 1921.

Steel ingot production in November was at the rate of about 23,750,000 gross tons a year, representing about 45 per cent of the total capacity, against rates of 44 per cent in October, 32 per cent in September, 30 per cent in August and 21 per cent in July. The October rate had been the highest since February.

While the comparison by months shows a continuous increase since July, the November output was not altogether as large as would be expected from the increases in operations that occurred late in October and early in November, and it is evident that a high point was reached not later than the middle of November, since when there has been declining production. A fair estimate is that the rate at present is scarcely over 40 per cent.

The decrease in steel production is a tardy reflection of the dullness that stole over the market at the middle of October, and as the market has not become more active lately, except in tubular goods, further decreases in the rate of operation are to be expected. It appears that some mills are making a special effort to run just now, to give employees some money for the holiday season, and it is not improbable that a number of mills will be closed in the last week or two of the month or the fore part of January.

CHARACTER OF DEMAND

In sheets there is a decreasing demand, chiefly or wholly on account of the season of the year. If allowance be made for the sheet tonnage that goes into large construction work and the manufacture of machinery, and allowance also be made for its being between seasons for the automobile trade, the sheet demand may be regarded as not far from normal. Tin-plate demand is normal for the season, and prospects are that 1922 will be a full normal year in tin-plate consumption. Wire products suffer chiefly from two influences, the season of the year and the fact that buying power of farmers is greatly restricted while the farmer is less disposed than usual to spend what money he has.

STEEL PRICES

Except for the cutting in line pipe and some descriptions of oil-country goods, noted above, steel prices are substantially unchanged. It is obvious that there is a sagging rather than any advancing tendency, but demand is so light, running almost wholly to very small orders, that there is little encouragement to sellers to shade prices. The real final "shake-out" in prices is still to come. It will come when buyers enter the market more freely and offer attractive orders for either prompt or extended delivery. The declines, however, will be quite small compared with what was occurring up to last August.

Bars, shapes and plates generally are quotable at not outside a range of 1.50@1.60c., showing no important change for several weeks. Sheets are quotable at 2.25c. for blue annealed, 3c. for black and 4c. for galvanized. They are well held at these prices, but the market is undergoing no serious test. The $4.75 tin-plate price is also holding well.

In wire products the swing back to prices ruling before the Sept. 12 advance is now almost complete, although the advanced prices are apparently obtained on small orders in many cases. Contracts entered in anticipation of the Sept. 12 advance were for 60 days, but have been extended where necessary.

PIG IRON

The increased activity in pig iron reported from some districts is not observed in the Pittsburgh valley market, where the only transaction of any consequence reported is a sale of 3,500 tons by a steel interest, out of surplus, to the Trumbull Steel Co., which in this connection abandons its plan of starting its blast furnace Jan. 1, so that the incident is not of a particularly bullish character. The market remains quotable at $20 for bessemer, $19 for basic and $20.50 for foundry, f.o.b. valley furnaces.

Connellsville coke is weaker still, furnace coke not being quotable at over $3, with possibilities of the price being shaded, while foundry coke of ordinary grade is not strong at $4. On contracts higher prices are of course asked, but there is scarcely any interest on the part of consumers.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	–	$0.40 – $0.45
Acetone	lb.	$0.12½ – $0.12½	.13 – .13½
Acid, acetic, 28 per cent	100 lbs.	2.75 – 3.00	3.25 – 3.50
Acetic, 56 per cent	100 lbs.	5.50 – 5.75	6.00 – 6.50
Acetic, glacial, 99½ per cent, carboys,	100 lbs.	10.00 – 10.50	10.75 – 11.00
Boric, crystals	lb.	.12½ – .12¾	.13 – .13½
Boric, powder	lb.	.13 – .13½	.14 – .14½
Citric	lb.	–	.44½ – .46
Hydrochloric	100 lb.	1.25 – 1.50	1.60 – 1.75
Hydrofluoric, 52 per cent	lb.	.12 – .12½	.12½ – .13
Lactic, 44 per cent tech	lb.	.09½ – .10	.10½ – .12
Lactic, 22 per cent tech	lb.	.04½ – .05½	.06 – .07
Molybdic, C.P.	lb.	3.25 – 3.50	3.60 – 4.00
Muriatic, 20 deg. (see hydrochloric)		–	–
Nitric, 40 deg.	lb.	.06½ – .06¾	.06½ – .07
Nitric, 42 deg.	lb.	.06½ – .07	.07½ – .07¾
Oxalic, crystals	lb.	.14½ – .15	.15½ – .16
Phosphoric, 50 per cent solution	lb.	.13 – .13½	.14 – .18
Picric	lb.	.20 – .25	.27 – .35
Pyrogallic, resublimed	lb.	–	1.90 – 2.00
Sulphuric, 60 deg., tank cars	ton	–	11.00 – 12.00
Sulphuric, 60 deg., drums	ton	–	13.00 – 15.00
Sulphuric, 66 deg., tank cars	ton	17.00 – 18.00	–
Sulphuric, 66 deg., drums	ton	21.00 – 22.00	22.50 – 23.00
Sulphuric, 66 deg., carboys	ton	–	–
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	21.00 – 22.00	–
Sulphuric, fuming, 20 per cent (oleum) drums	ton	23.00 – 23.50	24.00 – 24.50
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	31.00 – 32.00	33.00 – 34.00
Tannic, U. S. P.	lb.	–	.75 – .85
Tannic (tech.)	lb.	.45 – .48	.50 – .55
Tartaric, imported crystals	lb.	–	.26 – .26½
Tartaric acid, imported, powdered	lb.	–	.27 – .28
Tartaric acid, domestic	lb.	–	– .35
Tungstic, per lb. of WO	lb.	–	1.10 – 1.20
Alcohol, Ethyl	gal.	–	4.65 – 5.00
Alcohol, Methyl (see methanol)		–	–
Alcohol, denatured, 188 proof	gal.	–	.42 – .43
Alcohol, denatured, 190 proof	gal.	–	.43 – .44
Alum, ammonia, lump	lb.	.03½ – .03¾	.04 – .04½
Alum, potash, lump	lb.	.03½ – .04	.04½ – .04½
Alum, chrome lump	lb.	.08 – .08½	.08½ – .09
Aluminum sulphate, commercial	lb.	.01½ – .02	.02½ – .02½
Aluminum sulphate, iron free	lb.	.02½ – .02¾	.03 – .03½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.07½ – .07¾	.08 – .08½
Ammonia, anhydrous, cyl. (100-150 lb.)	lb.	.31 – .32	.33 – .35
Ammonium carbonate, powder	lb.	.07 – .07½	.08 – .09
Ammonium chloride, granular (white salammoniac)	lb.	.06½ – .07	.07½ – .07½
Ammonium chloride, granular (gray salammoniac)	lb.	.06½ – .07	.07½ – .07½
Ammonium nitrate	lb.	.07½ – .07¾	.07½ – .08½
Amylacetate tech.	gal.	–	2.40 – 2.65
Arsenic oxide, (white arsenic) powdered	lb.	.06 – .06½	.06½ – .07
Arsenic, sulphide, powdered (red arsenic)	lb.	.12 – .12½	.12½ – .13
Barium chloride	ton	48.00 – 49.00	50.00 – 55.00
Barium dioxide (peroxide)	lb.	.20 – .21	.22 – .23
Barium nitrate	lb.	.06½ – .07	.07½ – .08
Barium sulphate (precip.) (blanc fixe)	lb.	.04 – .04½	.04½ – .05
Bleaching powder (see calc. hypochlorite)		–	–
Blue vitriol (see copper sulphate)		–	–
Borax (see sodium borate)		–	–
Brimstone (see sulphur, roll)		–	–
Bromine	lb.	.27 – .28	.28½ – .30
Calcium acetate	100 lbs.	1.75 – 2.00	–
Calcium carbide	lb.	.04½ – .04¾	.05 – .05½
Calcium chloride, fused, lump	ton	23.50 – 24.00	24.50 – 25.50
Calcium chloride, granulated	lb.	.01½ – .02	.02½ – .02½
Calcium hypochloride (bleach'g powder)	100 lb.	2.50 – 2.60	2.65 – 3.25
Calcium peroxide	lb.	–	1.40 – 1.50
Calcium phosphate, tribasic	lb.	–	.15 – .16
Camphor	lb.	–	.91 – .95
Carbon bisulphide	lb.	.06½ – .06¾	.07 – .07½
Carbon tetrachloride, drums	lb.	.10½ – .10¾	.11 – .12
Carbonyl chloride, (phosgene)	lb.	–	.60 – .75
Caustic potash (see potassium hydroxide)		–	–
Caustic soda (see sodium hydroxide)		–	–
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.08 – .09	.09½ – .10
Chloroform	lb.	–	.40 – .43
Cobalt oxide	lb.	–	2.00 – 2.10
Copperas (see iron sulphate)		–	–
Copper carbonate, green precipitate	lb.	.19 – .19½	.20 – .21
Copper cyanide	lb.	–	.50 – .62
Copper sulphate, crystals	100 lb.	5.65 – 5.70	5.75 – 6.25
Cream of tartar (see potassium bitartrate)		–	–
Epsom salt (see magnesium sulphate)		–	–
Ethyl Acetate Com. 85%	gal.	–	.70 – .80
Ethyl Acetate pure (acetic ether, 98% to 100%)	gal.	–	.95 –
Formaldehyde, 40 per cent	lb.	.10½ – .11	.11½ – .12
Fusel oil, ref.	gal.	–	2.50 – 3.00
Fusel oil, crude	gal.	–	1.50 – 1.75
Glauber's salt (see sodium sulphate)		–	–
Glycerine, C. P. drums extra	lb.	–	.15 – .16
Iodine, resublimed	lb.	–	3.50 – 3.60
Iron oxide, red	lb.	–	.12 – .18
Iron sulphate (copperas)	ton	15.00 – 16.00	17.00 – 20.00
Lead acetate	lb.	–	.10½ – .12½
Lead arsenate, powd.	lb.	.15 – .15½	.15½ – .16½
Lead nitrate	lb.	–	.15 – .20
Litharge	lb.	.08 – .08½	.08½ – .09
Lithium carbonate	lb.	–	1.40 – 1.50
Magnesium carbonate, technical	lb.	.08 – .08½	.09 – .10
Magnesium sulphate, U. S. P.	100 lb.	2.50 – 2.75	–
Magnesium sulphate, technical	100 lb.	–	1.10 – 1.75
Methanol, 95%	gal.	–	.62 – .63
Methanol, 97%	gal.	–	.64 – .65
Nickel Salt, double	lb.	–	.12 – .12½
Nickel salt, single	lb.	–	.14 – .14½
Phosgene (see carbonyl chloride)		–	–
Phosphorus, red	lb.	.45 – .46	.47 – .50
Phosphorus, yellow	lb.	–	.32 – .35
Potassium bichromate	lb.	.11 – .11½	.11½ – .12

		Carlots	Less Carlots
Potassium bitartrate (cream of tartar)	lb.	$ – $	$0.25 – $0.26
Potassium bromide, granular	lb.	–	.15 – .20
Potassium carbonate, U. S. P.	lb.	.15 – .16	.17 – .20
Potassium carbonate, 80–85%	lb.	.04½ – .04¾	.05 – .06
Potassium chlorate, crystals	lb.	.06 – .06¼	.06½ – .12
Potassium cyanide	lb	–	.40 – .45
Potassium hydroxide (caustic potash)	lb.	.05¾ – .05¾	.06 – .08
Potassium iodide	lb.	–	2.60 – 2.75
Potassium nitrate	lb.	.07¼ – .07½	.08 – .09
Potassium permanganate	lb.	.17 – .18	.18½ – .21
Potassium prussiate, red	lb.	.28 – .29	.29½ – .30
Potassium prussiate, yellow	lb.	.22½ – .22¾	.23 – .23½
Rochelle salts (see sodium potas tartrate)			
Salammoniac (see ammonium chloride)			
Sal soda (see sodium carbonate)			
Salt cake (bulk)	ton	–	18.00 – 20.00
Silver cyanide	oz.	–	1.10 – 1.20
Silver nitrate	oz.	–	.45 – .46
Soda ash, light	100 lb.	1.75 – 2.10	2.15 – 2.50
Soda ash, dense	100 lb.	2.25 – 2.30	2.35 – 2.60
Sodium acetate	lb.	.04 – .04½	.04½ – .05
Sodium bicarbonate	100 lb.	2.30 – 2.35	2.40 – 2.75
Sodium bichromate	lb.	.07½ – .08	.08½ – .08½
Sodium bisulphate (nitre cake)	ton	5.00 – 5.25	5.50 – 6.50
Sodium bisulphite powdered, U.S.P.	lb.	.04½ – .05	.05½ – .06
Sodium borate (borax)	lb.	.05½ – .06	.06½ – .07
Sodium carbonate (sal soda)	100 lb.	1.80 – 1.90	2.00 – 2.20
Sodium chlorate	lb.	.06½ – .07	.07½ – .08
Sodium cyanide	lb.	.28 – .28½	.29 – .30
Sodium fluoride	lb.	.11 – .12	.12½ – .14
Sodium hydroxide (caustic soda)	100 lb.	3.90 – 4.00	4.05 – 4.50
Sodium hyposulphite		–	.03½ – .03¾
Sodium nitrite	lb.	.06½ – .07	.07½ – .07¾
Sodium peroxide, powdered	lb.	.25 – .26	.27 – .30
Sodium phosphate, dibasic	lb.	.04¼ – .04½	.04¾ – .05¼
Sodium potassium tartrate (Rochelle salts)	lb.	–	.21 – .24
Sodium prussiate, yellow	lb.	.14¼ – .14¾	.14½ – .15
Sodium silicate, solution (40 deg.)	100 lb.	1.00 – 1.05	1.10 – 1.30
Sodium silicate, solution (60 deg.)	100 lb.	2.30 – 2.40	2.45 – 3.00
Sodium sulphate, crystals (Glauber's salt)	100 lbs.	1.30 – 1.50	1.60 – 2.00
Sodium sulphide, fused, 60-62 per cent (conc.)	lb.	.04½ – .04¾	.05 – .05½
Sodium sulphite, crystals	lb.	.03½ – .03¾	.04 – .04½
Strontium nitrate, powdered	lb.	.13 – .14	.14½ – .20
Sulphur chloride, red	lb.	.06 – .06¼	.06½ – .07
Sulphur, crude	ton	18.00 – 20.00	–
Sulphur dioxide, liquid, cylinders extra	lb.	.08 – .08½	.09 – .10
Sulphur (sublimed), flour	100 lb.	–	2.25 – 3.10
Sulphur, roll (brimstone)	100 lb.	–	2.00 – 2.75
Tin bichloride	lb.	.09 – .09½	.09½ – .10
Tin oxide	lb.	–	.37 – .38½
Zinc carbonate	lb.	.14 – .14½	.15 – .16½
Zinc chloride, gran.	lb.	.09 – .09½	.09½ – .10
Zinc cyanide	lb.	.42 – .44	.45 – .47
Zinc dust	lb.	.11½ – .11½	.11¼ – .12½
Zinc oxide, XX	lb.	.07½ – .07¾	.08 – .09
Zinc sulphate	100 lb.	3.00 – 3.25	3.30 – 3.50

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha-naphthol, crude	lb.	$1.10 — $1.15
Alpha-naphthol, refined	lb.	1.25 — 1.30
Alpha-naphthylamine	lb.	.30 — .32
Aniline oil, drums extra	lb.	.18 — .20
Aniline salts	lb.	.24 — .26
Anthracene, 80% in drums (100 lb.)	lb.	.75 — 1.00
Benzaldehyde U.S.P.	lb.	1.35 — 1.45
Benzidine, base	lb.	.90 — 1.00
Benzidine sulphate	lb	.75 — .85
Benzoic acid, U.S.P.	lb.	.62 — .65
Benzoate of soda, U.S.P.	lb.	.52 — .55
Benzene, pure, water-white, in drums (100 gal.)	gal.	.27 — .32
Benzene, 90%, in drums (100 gal.)	gal.	.25 — .28
Benzyl chloride, 95-97%, refined	lb.	.25 — .27
Benzyl chloride, tech.	lb.	.20 — .23
Beta-naphthol benzoate	lb.	3.75 — 4.00
Beta-naphthol, sublimed	lb.	.70 — .75
Beta-naphthol, tech	lb.	.30 — .34
Beta-naphthyla mine, sublimed	lb.	1.75 — 1.85
Cresol, U. S. P., in drums (100 lb.)	lb.	.15 — .16
Ortho-cresol, in drums (100 lb.)	lb.	.24 — .26
Cresylic acid, 97–99%, straw color, in drums	gal.	.70 — .80
Cresylic acid, 95-97%, dark, in drums	gal.	.65 — .70
Cresylic acid, 50%, first quality, drums	gal.	.45 — .50
Dichlorbenzene	lb.	.06 — .09
Diethylaniline	lb.	.95 — 1.10
Dimethylaniline	lb.	.45 — .60
Dinitrobenzene	lb.	.23 — .27
Dinitroclorbenzene	lb.	.20 — .25
Dinitronaphthalene	lb.	.30 — .35
Dinitrophenol	lb.	.35 — .40
Dinitrotoluene	lb.	.25 — .30
Dip oil, 25%, car lots, in drums	gal.	.30 — .35
Diphenylamine	lb.	.60 — .70
H-acid	lb.	1.00 — 1.10
Meta-phenylenediamine	lb.	1.10 — 1.15
Monochlorbenzene	lb.	.12 — .14
Monoethylaniline	lb.	1.65 — 1.70
Naphthalene crushed, in bbls.	lb.	.07 — .08
Naphthalene, flake	lb.	.07 — .08
Naphthalene, balls	lb.	.08 — .09½
Naphthionic acid, crude	lb.	.70 — .75
Nitrobenzene	lb.	.12 — .15
Nitro-naphthalene	lb.	.30 — .35
Nitro-toluene	lb.	.15 — .17
Ortho-amidophenol	lb.	3.00 — 3.10
Ortho-dichlor-benzene	lb.	.15 — .20
Ortho-nitro-phenol	lb.	.77 — .80
Ortho-nitro-toluene	lb.	.15 — .20
Ortho-toluidine	lb.	.20 — .25
Para-amidophenol, base	lb.	1.40 — 1.45
Para-amidophenol, HCl	lb.	1.70 — 1.80
Para-dichlorbenzene	lb.	.12 — .15
Paranitroaniline	lb.	.75 — .80
Para-nitrotoluene	lb.	.80 — .85
Para-phenylenediamine	lb.	1.70 — 1.75
Para-toluidine	lb.	1.25 — 1.40
Phthalic anhydride	lb.	.40 — .50
Phenol, U. S. P., drums	lb.	.10½ — .15
Pyridine	gal.	2.00 — 3.50
Resorcinol, technical	lb.	1.50 — 1.60
Resorcinol, pure	lb.	2.00 — 2.25
Salicylic acid, tech., in bbls.	lb.	.20 — .21
Salicylic acid, U. S. P.	lb.	.22 — .23
Salol	lb.	.70 — .72
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.25 — .28
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.14 — .16
Sulphanilic acid, crude	lb.	.27 — .30
Tolidine	lb.	1.30 — 1.35
Toluidine, mixed	lb.	.43 — .45
Toluene, in tank cars	gal.	.25 — .28
Toluene, in drums	gal.	.28 — .31
Xylidines, drums, 100 gal.	lb.	.40 — .45
Xylene, pure, in drums	gal.	.40 — .45
Xylene, pure, in tank cars	gal.	.45 —
Xylene, commercial, in drums, 100 gal.	gal.	.33 — .35
Xylene, commercial, in tank cars	gal.	.30 —

Waxes

Prices based on original packages in large quantities.

Bayberry Wax	lb.	$0.20 — $0.21
Beeswax, refined, dark	lb.	.24 — .25
Beeswax, refined, light	lb.	.28 — .30
Beeswax, white pure	lb.	.34 — .38
Candellila wax	lb.	.24 — .24½
Carnauba, No. 1	lb.	.45 — .46
Carnauba, No. 2, North Country	lb.	.23 — .23½
Carnauba, No. 3, North Country	lb.	.14 — .14½
Japan	lb.	.21 — .21½
Montan, crude	lb.	.04½ — .04½
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.04½ — .04½
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.03½ —
Paraffine waxes, refined, 118-120 m.p.	lb.	.03¾ — .04
Paraffine waxes, refined, 125 m.p.	lb.	.04 — .04½
Paraffine waxes, refined, 128-130 m.p.	lb.	.04½ — .04½
Paraffine waxes, refined, 133-135 m.p.	lb.	.05 — .05½
Paraffine waxes, refined, 135-137 m.p.	lb.	.05½ — .05¾
Stearic acid, single pressed	lb.	.09¼ —
Stearic acid, double pressed	lb.	.09¾ —
Stearic acid, triple pressed	lb.	.10½ — .10¾

Naval Stores

All prices are f.o.b. New York unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Rosin B-D, bbl.	280 lb.	$5.30 —	5.35
Rosin E-I	280 lb.	5.40 —	5.50
Rosin K-N	280 lb.	6.05 —	6.75
Rosin W. G.-W. W.	280 lb.	7.00 —	7.25
Wood rosin, bbl.	280 lb.	6.25 —	
Spirits of turpentine	gal.	.82 —	
Wood turpentine, steam dist.	gal.	.80 —	
Wood turpentine, dest. dist.	gal.	.78 —	
Pine tar pitch, bbl.	200 lb.	—	6.00
Tar, kiln burned, bbl. (500 lb.)	bbl	—	9.50
Retort tar, bbl.	500 lb.	—	9.50
Rosin oil, first run	gal.	.36 —	
Rosin oil, second run	gal.	.39 —	
Rosin oil, third run	gal.	.46 —	
Pine oil, steam dist., sp.gr., 0.930-0.940	gal.		$1.90
Pine oil, pure, dest. dist.	gal.		1.50
Pine tar oil, ref., sp.gr. 1.025-1.035	gal.		.46
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.		.35
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.		.75
Pine tar, ref., thin, sp.gr., 1.080-1.960	gal.		.35
Turpentine, crude, sp. gr., 0.900-0.970	gal.		1.25
Hardwood oil, f.o.b. Mich., sp.gr., 0.960-0.990	gal.		.35
Pinewood creosote, ref.	gal.		.52

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.37
70-72 deg., steel bbls. (85 lb.)	gal.	.35
68-70 deg., steel bbls. (85 lb.)	gal.	.34
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23

Fertilizers

Ammonium sulphate, bulk and d. bags	100 lb.	$2.30 —	2.90
Blood, dried, f.o.b., N. Y.	unit	4.00	
Bone, 3 and 50, ground, raw	ton	30.00 —	32.00
Fish scrap, dom., dried, f.o.b. works	unit	2.90 —	3.00
Nitrate soda	100 lb.	2.30 —	2.35
Tankage, high grade, f.o.b. Chicago	unit	2.75 —	3.00
Phosphate rock, f.o.b. mines, Florida pebble, 68-72 p.c.	ton	4.50 —	6.50
Tennessee, 78-80 p.c.	ton	8.50 —	9.00
Potassium muriate, 80 p.c.	ton	35.00 —	37.00
Potassium sulphate	unit	.90 —	1.00

Crude Rubber

Para—Upriver fine	lb.	$0.23 —	.23½
Upriver coarse	lb.	.13½ —	.14
Upriver caucho ball	lb.	.13 —	.13½
Plantation—First latex crepe	lb.	.18½ —	.18¾
Ribbed smoked sheets	lb.	.18½ —	.19
Brown crepe, thin, clean	lb.	.15 —	
Amber crepe No. 1	lb.	.17½ —	

Oils

VEGETABLE

The following prices are f.o.b. New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.10½ —	$0.10¾
Castor oil, AA, in bbls.	lb.	.11½ —	.12
China wood oil, in bbls. (f.o.b. Pac. coast)	lb.	.13½ —	.13¾
Cocoanut oil, Ceylon grade, in bbls.	lb.	.09 —	.09½
Cocoanut oil, Cochin grade, in bbls.	lb.	.10½ —	.10¾
Corn oil, crude, in bbls.	lb.	.08½ —	.08¾
Cottonseed oil, crude (f. o. b. mill)	lb.	.07 —	.07¼
Cottonseed oil, summer yellow	lb.	.08¾ —	.09
Cottonseed oil, winter yellow	lb.	.09½ —	.09¾

Linseed oil, raw, car lots (domestic)	gal.	.67 —	.68
Linseed oil, raw, tank cars (domestic)	gal.	.62 —	.63
Linseed oil, in 5-bbl lots (domestic)	gal.	.70 —	.71
Olive oil, Denatured	gal.	$1.15 —	$1.20
Palm, Lagos	lb.	.07 —	.07½
Palm, Niger	lb.	.06½ —	.06¾
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.08½ —	.08¾
Peanut oil, refined, in bbls	lb.	.11 —	.11½
Rapeseed oil, refined in bbls	gal.	.83 —	.84
Rapeseed oil, blown, in bbls	gal.	.88 —	.90
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.09 —	....
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.07½ —	....
FISH			
Light pressed menhaden	gal.	$0.40 —	....
Yellow bleached menhaden	gal.	.42 —	....
White bleached menhaden	gal.	.45 —	....
Blown menhaden	gal.	.48 —	....

Miscellaneous Materials

All f.o.b. New York Unless Otherwise Stated

Barytes, ground, white, f.o.b. Kings Creek, S. C.	net ton	$23.00 —	23.50
Barytes, ground, off color, f.o.b. Kings Creek	net ton	15.00 —	17.00
Barytes, crude, 88%@94% ba., Kings Creek	net ton	10.00 —	12.00
Barytes, floated, f.o.b. St. Louis	net ton	23.00 —	24.00
Barytes, crude, first grade, Missouri	net ton	6.00 —	7.00
Blanc fixe, dry	lb.	.04 —	.04½
Blanc fixe, pulp	net ton	45.00 —	55.00
Casein	lb.	.15 —	.16
Chalk, Precipitated, domestic, extra light	lb.	.04½ —	.05
Chalk, Precipitated, domestic, light	lb.	.04 —	.04½
Chalk, Precipitated, domestic, heavy	lb.	.03½ —	.04
Chalk, Precipitated, English, extra light	lb.	.04½ —	.05
Chalk, Precipitated, English, light	lb.	.04½ —	.05
Chalk, Precipitated, English, dense	lb.	.04 —	.04½
China clay (kaolin) crude, f.o.b. mines, Georgia	net ton	6.50 —	8.50
China clay (kaolin) washed, f.o.b. Georgia	net ton	9.00 —	10.00
China clay (kaolin) powdered, f.o.b. Georgia	net ton	13.00 —	20.00
China clay (kaolin) crude f.o.b. Virginia points	net ton	8.00 —	12.00
China clay (kaolin) ground, f.o.b. Virginia points	net ton	13.00 —	20.00
China clay (kaolin), imported, lump	net ton	12.00 —	20.00
China clay (kaolin), imported, powdered	net ton	25.00 —	30.00
Feldspar, crude, f.o.b. Maryland and North Carolina points	net ton	5.00 —	7.50
Feldspar, crude, f.o.b. Maine	net ton	7.50 —	10.00
Feldspar, ground, f.o.b. Maine	net ton	21.00 —	23.00
Feldspar, ground, f.o.b. North Carolina	net ton	17.00 —	21.00
Feldspar, ground, f.o.b. N. Y. State	net ton	17.00 —	21.00
Feldspar, ground, f.o.b. Baltimore	net ton	27.00 —	30.00
Fullers earth, f.o.b. Mines	net ton	16.00 —	17.00
Fullers earth, granular, f.o.b. Pa	net ton	15.00 —	18.00
Fullers earth, powdered, f.o.b. Fla	net ton	18.00 —	....
Fullers earth, imported, powdered	net ton	24.00 —	27.00
Graphite, Ceylon lump, first quality	lb.	.06 —	.07
Graphite, Ceylon chip	lb.	.04½ —	.05
Graphite, high grade amorphous crude	lb.	.00½ —	.02½
Kieselguhr, f.o.b. mines, Cal	per ton	40.00 —	....
Kieselguhr, f.o.b. N.Y.	per ton	55.00 —	60.00
Magnesite, calcined	per ton	50.00 —	65.00
Pumice stone, imported	lb.	.03 —	.40
Pumice stone, domestic, lump	lb.	.05 —	.05½
Pumice stone, domestic, ground	lb.	.06 —	.07
Quartz (acid tower) first to head, f.o.b. Baltimore	net ton	..... —	10.00
Quartz (acid tower) 1½@2 in., f.o.b. Baltimore	net ton	..... —	14.00
Quartz (acid tower) rice, f.o.b. Baltimore	net ton	..... —	17.00
Quartz, lump, f.o.b. North Carolina	net ton	5.00 —	7.50
Shellac, orange fine	lb.	.68 —	.70
Shellac, orange superfine	lb.	.78 —	.80
Shellac, A. C. garnet	lb.	.58 —	.60
Shellac, T. N.	lb.	.68 —	.70
Soapstone	ton	12.00 —	15.00
Sodium chloride	long ton	12.50 —	13.00
Talc, paper-making grades, f.o.b. Vermont	ton	11.00 —	18.00
Talc, roofing grades, f.o.b. Vermont	ton	8.50 —	13.00
Talc, rubber grades, f.o.b. Vermont	ton	11.00 —	18.00
Talc, powdered, Southern, f.o.b. cars	ton	7.50 —	11.00
Talc, imported	ton	30.00 —	40.00
Talc, California talcum powder grade	ton	18.00 —	25.00

Refractories

Bauxite brick, 56% Al, f.o.b. Pittsburgh	per ton		$50.00
Carborundum refractory brick, 9-in.	less than carlot	1.000	1250.00
	carload lots	1.000	1100.00
Chrome brick, f.o.b. Eastern shipping points	net ton		52- 55
Chrome cement, 40-45% Cr_2O_3	net ton		30- 32
Chrome cement, 40-45% Cr_2O_3, sacks, in car lots, f.o.b. Eastern shipping points	net ton		33- 35
Fireclay brick, 1st quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000		35- 40
Fireclay brick, 2nd quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000		30- 35
Magnesite brick, 9-in. straight	net ton		65- 70
Magnesite brick, 9-in. arches, wedges and keys	net ton		77
Magnesite brick, soaps and splits	net ton		98
Silica brick, 9-in. sizes, f.o.b Chicago district	1,000		40- 42
Silica brick, 9-in. sizes, f.o.b. Birmingham district	1,000		42- 45
Silica brick, 9-in. sizes, f.o.b. Mt. Union, Pa	1,000		35- 38

Ferro-Alloys

All f.o.b. Works

Ferrocarbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00 —	$225.00
Ferrochrome per lb. of Cr. contained, 6-8% carbon, carlots	lb.	.12 —	....
Ferrochrome, per lb. of Cr. contained, 4-6% carbon, carlots	lb.	.13 —	....
Ferromanganese, 76-80% Mn, domestic	gross ton	58.00 —	60.00
Ferromanganese, 76-80% Mn, Foreign, C. I. F. Atlantic Seaport	gross ton	54.00 —	58.35
Spiegeleisen, 18-22% Mn	gross ton	25.00 —	27.00
Ferromolybdenum, 50-60% Mo, per lb. of Mo	lb.	2.25 —	....
Ferrosilicon, 10-15%	gross ton	38.00 —	40.00
Ferrosilicon, 50%	gross ton	57.00 —	59.00
Ferrosilicon, 75%	gross ton	120.00 —	125.00
Ferrotungsten, 70-80%, per lb. of contained W	lb.	.40 —	.45
Ferrouranium, 35-50% of U, per lb. of U content	lb.	6.00 —	....
Ferrovanadium, 30-40% per lb. of contained V	lb.	4.25 —	4.50

Ores and Semi-finished Products

All f.o.b. New York, Unless Otherwise Stated

Bauxite, 52% Al content	net ton	$8.00 —	$10.00
Chrome ore, Calif. concentrates, 50% min. Cr_2O_3	ton	22.00 —	23.00
Chrome ore, 50% Cr_2O_3, f.o.b. Atlantic seaboard	ton	22.00 —	23.00
Coke, foundry, f.o.b. ovens	net ton	4.25 —	4.50
Coke, furnace, f.o.b. ovens	net ton	3.25 —	3.50
Fluorspar, gravel, f.o.b. mines, New Mexico	net ton	12.00 —	....
Fluorspar, standard, domestic washed gravel Kentucky and Illinois mines	net ton	20.00 —	22.00
Ilmenite, 52% TiO_2, per lb. ore	lb.	.01½ —	.01¾
Manganese ore, 50% Mn, c.i.f. Atlantic seaport	unit	.23 —	.24
Manganese ore, chemical (MnO_2)	net ton	55.00 —	60.00
Molybdenite, 85% MoS_2, per lb. of MoS_2, N. Y.	lb.	.45 —	.50
Monazite, per unit of ThO_2, c.i.f., Atlantic seaport	unit	30.00 —	....
Pyrites, Spanish, fines, c.i.f., Atlantic seaport	unit	.12 —	.12
Pyrites, Spanish, furnace size, c.i.f. Atlantic seaport	unit	.13 —	.13
Pyrites, domestic, fines, f.o.b. mines, Ga	unit	.11 —	.12
Rutile, 95% TiO_2 per lb. ore	lb.	.15 —	....
Tungsten, scheelite, 60% WO_3 and over, per unit of WO_3 (nominal)	unit	2.50 —	2.75
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3, N. Y. C.	unit	2.75 —	3.00
Uranium ore (carnotite) per lb. of U_3O_8	lb.	1.25 —	1.75
Uranium oxide, 96% per lb. contained U_3O_8	lb.	2.25 —	2.50
Vanadium pentoxide, 99%	lb.	12.00 —	14.00
Vanadium ore, per lb. of V_2O_5 contained	lb.	1.00 —	....
Zircon, washed, iron free, f.o.b. Pablo, Florida	lb.	.04½ —	.13

Non-Ferrous Metals

New York Markets

	Cents per Lb.
Copper, electrolytic	13.75
Aluminum, 98 to 99 per cent	19.00
Antimony, wholesale lots, Chinese and Japanese	4.50
Nickel, ordinary (ingot)	41.00
Nickel, electrolytic	44.00
Monel metal, shot and blocks	35.00
Monel metal ingots	38.00
Monel metal, sheet bars	40.00
Tin, 5-ton lots, Straits	31.50
Lead, New York, spot	4.70
Lead, E. St. Louis, spot	4.35@4.40
Zinc, spot, New York	5.30@5.35
Zinc, spot, E. St. Louis	4.85@4.90

OTHER METALS

Silver (commercial)	oz.	$0.66⅛
Cadmium	lb.	1.00–1.25
Bismuth (500 lb. lots)	lb.	1.50@1.55
Cobalt	lb.	3.00@3.25
Magnesium (f.o.b. Philadelphia)	lb.	1.25
Platinum	oz.	80.00
Iridium	oz.	150.00@170.00
Palladium	oz.	55.00–60.00
Mercury	75 lb.	46.00–47.00

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	21.25
Copper bottoms	28.75
Copper rods	19.75
High brass wire	17.25
High brass rods	14.75
Low brass wire	18.75
Low brass rods	19.25
Brazed brass tubing	25.50
Brazed bronze tubing	30.50
Seamless copper tubing	21.25
Seamless high brass tubing	18.50

OLD METALS—The following are the dealers' purchasing prices in cents per pound:

	New York Current	Cleveland	Chicago
Copper, heavy and crucible	9.75@10.25	9.25	9.50
Copper, heavy and wire	9.25@9.50	8.50	8.50
Copper, light and bottoms	7.50@8.00	7.50	7.25
Lead, heavy	3.50@3.75	3.25	3.25
Lead, tea	2.25@2.35	2.25	2.25
Brass, heavy	4.25@4.50	4.50	5.00
Brass, light	3.25@3.50	3.25	3.50
No. 1 yellow brass turnings	4.00@4.25	4.25	4.50
Zinc	2.00@2.25	2.00	2.25

Structural Material

The following base prices per 100 lb. are for structural shapes 3 in. by ¼ in. and larger, and plates ¼ in. and heavier, from jobbers' warehouses in the cities named:

	New York	Cleveland	Chicago
Structural shapes	$2.78	$2.88	$2.78
Soft steel bars	2.68	2.78	2.68
Soft steel bar shapes	2.68	2.78	2.68
Soft steel bands	3.28	3.48	3.28
Plates, ¼ to 1 in. thick	2.78	2.88	2.78

*Add 15c per 100 lb. for trucking to Jersey City and 10c for delivery in New York and Brooklyn

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

Arkansas

BATESVILLE—The American Manganese Co. has awarded a contract to the E. C. McCombs Co. for the completion of the concentrating plant at its Polk Southard Mines, to be equipped for a daily output of about 25 tons. The plant is estimated to cost about $150,000.

California

CHICO—The Standard Oil Co. has awarded a contract to J. J. Brooks, Sacramento, Cal., for the rebuilding of its local oil-distributing plant on Nord Ave., estimated to cost about $25,000. Work will be begun at once.

LONG BEACH—The Red Seal Refining Co. has acquired property on West Anaheim St. as a site for the erection of a new oil refinery, estimated to cost close to $1,000,000, with machinery. Plans will be drawn at an early date. H. L. Hagerman is treasurer.

Connecticut

NEW HAVEN—Fire, Dec. 1, destroyed a portion of the plant of the Seamless Rubber Co., Hallock Ave., with loss estimated at close to $100,000. The company is a subsidiary of the United Drug Co., Boston, Mass.

WINDSOR LOCKS—Following the acquisition of the Windsor Lock Paper Mills by the J. N. L. Smythe Co., 32-34 South Sixth St. Philadelphia, Pa., the former company has been dissolved and a new corporation formed under state laws and name of the Windsor Lock Paper Mills Co., Inc., capitalized at $200,000. The new company will increase the capacity of the plant. The incorporators are A. T. Johnson. A. W. Hyde and J. H. Williams, 261 White St., Hartford, Conn.

Illinois

CHICAGO—The Crane Co., 836 South Michigan Ave., manufacturer of sanitary fixtures, steam specialties, etc., is having plans prepared for the erection of a 2-story foundry at 4100 South Kedzie Ave., to be 160 x 500 ft. and estimated to cost in excess of $700,000 with equipment. Graham, Anderson, Probst & White, 8 East Jackson Blvd., are architects W. J. Clark, company address, is construction engineer.

CHICAGO—The Abbott Laboratories, 4753 Ravenswood Ave., manufacturers of chemicals, have construction under way on a new plant at Fourteenth and State Sts., North Chicago, estimated to cost about $400,000. It will consist of a number of buildings, with main structure 4-story and basement. It is proposed to expand the present plant in the spring and ground for additional structures will be broken at that time. E. H. Ravenscroft is vice-president in charge of construction.

CHICAGO—The Nemo Dye Works is building a new 1-story mill and steel construction factory, 209 x 215 ft., for commercial dyeing at 4203 Grand Ave. Paul Gerhardt is architect; estimated cost, $250,000.

CHICAGO—Barrett & Barrett Mfg. Co., producer of apple products, is building a 7-story factory 100 x 61 ft. at 357 West Ontario St. Paul Gerhardt is architect; estimated cost, $300,000.

Indiana

JONESBORO—The Indiana Rubber Co., Pearl and First Sts., is planning for the construction of a 3-story addition, 60 x 125 ft. Plans will be drawn and work commenced in the coming spring.

TERRE HAUTE—The Columbian Enameling & Stamping Co. has construction under way on a 1-story and part basement addition, to be used for enameling and other operations. Roehm Bros., 30 North Fifth St., are contractors.

Kentucky

OWENSBORO—The Indian Refining Co., Lawrenceville, Ill., is planning for the construction of a new local distributing plant, with extensive pipe-line and pumping system for oil service, estimated to cost in excess of $500,000.

LOUISVILLE — The Standard Sanitary Mfg. Co., Bessemer Bldg., Pittsburgh, Pa., is completing plans for the erection of its proposed local plant addition, Sixth and A Sts., to be 1-story, 56 x 375 ft., and estimated to cost close to $100,000. It will be equipped as an enameling works. O. P. Ward, Lincoln Building, Louisville, is architect.

Massachusetts

REVERE—The Suburban Gas & Electric Co., 150 Beach St., has awarded a contract to the C. H. Tenney Co., 201 Devonshire St., Boston, Mass., for the erection of a gas holder, with auxiliary gas works, on Proctor St., estimated to cost about $185,000.

Michigan

DETROIT—The Goodyear Tire & Rubber Co., 88 Custer Ave., has completed plans and is taking bids for extensions and improvements in its plant on Hastings St., near the Grand Blvd. Smith, Hinchman & Grylls, 710 Washington Arcade, are architects.

Missouri

KANSAS CITY— The Corn Products Refining Co. is planning for the early operation of its new local plant, in course of erection for a number of months past, and proposes to develop an extensive grinding capacity and output shortly after the first of the year. The plant will represent an investment of close to $4,000,000.

Nevada

CALLVILLE—The West End Chemical Co. is planning for extensive developments and operations at its local borax properties for the production of colemanite and refined borax. Work will be concentrated to handle a contract calling for a minimum of 60,000 tons of colemanite and a maximum of 240,000 over a certain number of months. F. M. (Borax) Smith, San Francisco, Cal., is president of the company.

New Jersey

TRENTON — The General Chinaware Corp. has acquired the old Willits pottery, and will establish a new local plant for the manufacture of dinnerware products. Machinery will be installed at once using only a portion of the plant at the present time. The remainder will be leased for other manufacturing service.

NEWARK—The Linden Tanning Co., 440 Frelinghuysen Ave., has filed plans for the erection of an addition to its plant.

NEWARK—The Gulf Refining Co., Doremus Ave., will commence the immediate erection of a 2-story building at its plant, estimated to cost about $60,000.

New York

CUYLERVILLE—The Sterling Salt Company of New York has contracted with Dwight P. Robinson & Co., Inc., of New York City for the design and construction of a salt warehouse and conveying equipment here.

North Carolina

MOUNT HOLLY—The Kendrick Brick & Tile Co. has plans under way for enlargements in its plant, to include the installation of new machinery, drying equipment and other apparatus. It is proposed to increase the production from 75,000 to over 100,000 bricks a day. N. B. Kendrick heads the company.

WILMINGTON—The Texas Oil Co., 701 Barrone St., New Orleans, La., has acquired a tract of property totaling about 35 acres at Wilmington, for the construction of a new oil-distributing plant. At a later date, it is proposed to use a portion of the site for an oil refinery. The company is operating a plant in Mississippi.

Ohio

LORAIN—The Briggs Chemical Co. is planning for the rebuilding of the portion of its plant, destroyed by fire, Nov. 18, with loss estimated at about $60,000. A H. Babcock is president.

Oklahoma

McALESTER—The Chamber of Commerce is developing plans for the organization of a local company for the establishment of a brick-manufacturing plant, estimated to cost about $75,000, including machinery. A tile department will also be installed, with output of about 20,000 roofing tiles per day. The brick plant will be equipped for a daily production of 60,000 bricks.

ARDMORE—The Coline Oil Co. has acquired a tract of local property totaling about 40 acres to be used for the erection of a tank farm and oil-distributing works. The initial installation will consist of twenty-five 55,000-bbl. steel tanks.

Oregon

GRESHAM—John A. Moge has acquired a local site for the construction of a new foundry for the production of iron and other metal castings.

Pennsylvania

NEW HOPE—The American Clay Products Co. is planning to have its local plant, in course of erection for some months past, ready for service early in the coming year. Work is now under way on kilns and other manufacturing departments. The plant will be devoted to the production of vitrified brick and it is proposed to provide ultimately for an output of close to 500,000 bricks per day.

READING—The Colonial Chemical Co., Schuylkill Ave. and River Road, has preliminary plans under way for the erection of a new 2-story plant, 25 x 100 ft. High & Huber, 11 North Fifth St., are architects.

PHILADELPHIA—Philip Hauck & Son, 1237-39 North Fourth St., will soon commence the erection of an addition to their paper and paper box plant, to be 3-story, 37 x 90 ft.; and estimated to cost close to $30,000. Harry H. Wehmeyer, 509 West Cumberland St., has the construction contract.

PHILADELPHIA—Fire, Dec. 1, damaged a portion of the plant of F. Weber & Co., 1220 Buttonwood St., manufacturers of paints, oils, chemicals and other artists' materials, with loss reported in excess of $300,000.

Tennessee

NASHVILLE — The Farmers' Mutual Phosphate Co., 1047-48 Lemcke Annex, Indianapolis, Ind., is planning for the erection of a new plant at its properties at Centerville, near Nashville, to be known as Plant No. 3, with daily capacity of about 300 tons of phosphate, and a new mixing plant on an Indiana site. To carry out the details of the project, the company has arranged for a bond issue of $250,000. The company is now operating a 300-ton plant at Centerville, and a 100-ton operating unit is nearing completion; it will be placed in service in January.

Texas

KINGSVILLE—The Kingsville Commission Co. is considering the erection of a new leather tannery. Plans will be prepared at an early date. Marcus Phillips is manager.

DALLAS—L. D. Lansdale and Charles A. Mangold, both of Dallas are perfecting plans for the construction of a new plant on the site of the Love Field repair depot of the government for the manufacture of sulphuric acid. A company will be organized to operate the plant, which will have an initial capacity of about 50 tons per day, and estimated to cost close to $200,000, including machinery. One of the plant units will be devoted to the production of electrolyte acid for battery service. George A. Sprague, Dallas, is also interested in the new company.

CORPUS CHRISTI—T. B. Williams, Box 290, is organizing a new company to construct and operate a local leather tannery. Plans and details of the new plant will be arranged at an early date.

MARSHALL—The Darco Co., a subsidiary of the Atlas Powder Co., du Pont Bldg., Wilmington, Del., with headquarters at the same location, has broken ground for its proposed new local plant for the production of a new type of carbon. The initial works will have an annual output of about 6,000 tons of material, and will cost in excess of $500,000. W. J. Webster is president.

WACO—The Waco Oil & Refining Co. is considering plans for enlargements in its oil refinery for increased capacity. It is proposed to build a new pipe line from the

Mexia, Tex., fields to the local plant. W. A. Rogers is president.

Wisconsin

GREEN BAY—The Fort Howard Paper Co. has construction in progress for a 3-story paper mill in the East Side section, to be 100 x 120 ft., and estimated to cost about $85,000. The building contract has been awarded to the Rudolph M. Hansen Co., 113 Walnut St.

MILWAUKEE—The American Hide & Leather Co., Fourteenth St., is taking bids for the rebuilding of its local tannery, recently destroyed by fire, and will soon award contract. The works will comprise four buildings, with main structure, 200 x 300 ft., 4-story, estimated to cost close to $700,000, including equipment. Lockwood, Greene & Co., 38 South Dearborn St., Chicago, Ill., are architects. R. A. Riker is superintendent.

Capital Increases, Etc.

THE CONNECTICUT METAL & CHEMICAL Co., New Britain, Conn., has filed notice of change of name to the Stanley Chemical Co.

THE NEWARK PAPER BOX Co., 95 Eighth Ave., Newark, N. J., has filed notice of increase in capital from $10,000 to $200,000.

THE SAN ANTONIO PORTLAND CEMENT Co., San Antonio, Tex., has filed notice of increase in capital from $250,000 to $300,000.

Ray F. Hamlin and John M. Crawford have been appoined receivers for the AVALON RUBBER MFG. Co., Akron, O.

THE SUN RIVER CHEMICAL Co., 1914 Broadway, New York, N. Y., has filed notice of increase in capital from $300,000 to $400,000.

THE METAL STAMPING Co., Thirteenth St., Brooklyn, N. Y., has filed notice of increase in capital from $25,000 to $1,000,000.

THE SOUTH PORTO RICO SUGAR Co., 62 Cedar St. New York, N. Y., is arranging for a bond issue of $6,000,000, for general operations, expansion, etc.

THE ERIE-BUFFALO TUBE Co., Erie, Pa., has recently filed a voluntary petition in bankruptcy, with liabilities stated at $158,092.29, and assets, $238,816.10.

THE VACAMA MICA Co, a Delaware corporation, has filed notice of intention to operate at Waynesboro, Pa.

THE CARTHAGE SULPHITE PULP & PAPER Co., Carthage, N. Y., has arranged for a bond issue of $600,000, the proceeds to be used for general operations, expansion, etc.

THE PIERCE OIL CORP., 25 Broad St., New York, N. Y., has disposed of a bond issue of $2,000,000, the proceeds to be used for general operations, financing, etc.

An involuntary petition in bankruptcy has been filed against the PULP & FIBRE PRODUCTS Co., Scotch Plains, N. J.

New Companies

THE FLORIDA-LOUISIANA REFINING Co., Shreveport, La., has been incorporated under Florida laws with capital of $150,000, to manufacture refined oil products, with proposed plant in the vicinity of Jacksonville, Fla. H. C. Leete is president and general manager; and A. C. Lea, treasurer, both of Shreveport.

PETER BARAN & SONS, INC., Harrison, N. J., has been incorporated with a capital of $125,000, to manufacture leather products. The incorporators are Arthur Read, William V. Azzoli and Peter Baran, First and Bergen Sts., Harrison.

THE BERRYMAN RUBBER & TIRE Co., New York, N. Y., has been incorporated with a capital of $200,000 to manufacture automobile tires and other rubber products. The incorporators are H. M. Wise, E. Gibbs and E. J. Sisley. The company is represented by Lee, Aron & Wise, 7 Dey St., New York.

MILLBOND CHEMICALS, LTD., Boston, Mass., has been incorporated with a capital of $50,000, to manufacture chemicals and chemical byproducts. Julius Robbins is president; Benjamin Zakon, vice-president; and Milton H. Balch, 104 Temple St., West Newton, Mass., treasurer.

THE JORDAN PAPER BOX Co., 339 North Crawford Ave., Chicago, Ill., has been incorporated with a capital of 200 shares of stock, no par value, to manufacture paper boxes and allied paper products. The incorporators are George S. Marks, Frank H. and William R. Jordan.

THE MATTERN OIL & GREASE Co., Oil City, Pa., has been incorporated with a capital of $20,000, to manufacture lubricating oils, greases and kindred products. R. B. Mattern, Oil City, is treasurer.

THE LAMSON ASPHALT & CHEMICAL Co., New York, N. Y., has been incorporated under Delaware laws with capital of $150,000, to manufacture chemicals, dyestuffs and kindred products. The company is represented by the United States Corporation Co., 65 Cedar Street, New York.

THE CONNECTICUT HARD RUBBER Co, 600 State St., New Haven, Conn., has been organized under state laws to manufacture rubber products. J. A. Moffitt, 25 West 45th St., New York, is president; and A. A. Smith, 96 Howard St., New Haven, secretary and treasurer.

THE KUYKENDAL CHEMICAL Co., Columbia, S. C., has been incorporated with a capital of $50,000, to manufacture chemicals and chemical byproducts. The incorporators are C. M. and F. R. Kuykendal, both of Rock Hill, S. C.

THE WALLABOUT PAPER SPECIALTIES CORP., Brooklyn, N. Y., has been incorporated with a capital of $30,000, to manufacture paper products. The incorporators are J. Karper, L. and J. Blazer. The company is represented by Samuel Blazer, 52 Wall St., New York.

THE UNITED GULF STATES OIL COMPANIES, INC., New York, N. Y., has been incorporated under Delaware laws with capital of $10,000,000, to manufacture petroleum products. The incorporators are H. E. Ellis, J. L. Cunningham and W. H. Mayhar. The company is represented by the Charter Service Corp., 149 Broadway, New York.

THE M. C. S. CHEMICAL CORP., Jersey City, N. J. has been incorporated with a capital of $50,000, to manufacture chemicals and chemical byproducts. The incorporators are E. Burke Finnerty, Morris B. Dorman and Frank W. Hastings, Jr., 15 Exchange Pl., Jersey City.

THE MT. JEWETT FIRECLAY Co., Bradford, Pa., has been incorporated with a capital of $50,000, to operate fireclay and other clay properties. R. G. Vogel, Bradford, is treasurer.

THE NORTON LEATHER Co., Salem, Mass., has been incorporated with a capital of $50,000, to manufacture leather products. Michael H. Norton is president; and Joseph P. Norton, 100 School St., Salem, treasurer.

THE FRANCO-UTAH OIL Co., Salt Lake City, Utah, has been incorporated under Delaware laws, wih capital of $5,000,000, to manufacture petroleum products. The incorporators are D. H. Gustaveson and J. W. Musser, both of Salt Lake City. The company is represented by the Corporation Service Co., Wilmington, Del.

THE ESSEX PRODUCTS Co., Main and Terry Sts., Belleville, N. J., has been incorporated with a capital of $125,000, to manufacture chemicals and chemical byproducts. The incorporators are Howard R. Lewis and Harry V. Fisher.

THE CONSOLIDATED STAMPING & MFG. Co., Gaylord and Plymouth Sts., Detroit, Mich., has been incorporated with a capital of $500,000, to manufacture stamped metal and other metal products. The incorporators are Archibald A. Hitchcock, Harry M. Coates, and Robert T. Carr, 54 Tyler Ave., Highland Park, Mich.

THE RED DIAMOND CHEMICAL Co., Wilmington, Del., has been incorporated with a capital of $100,000 under state laws, to manufacture chemicals and chemical byproducts. The company is represented by the Corporation Service Co., Wilmington.

THE GREAT EASTERN REFINING CORP., Huntington, W. Va., has been incorporated with a capital of $200,000, to manufacture refined oil products. The incorporators are Fred W. Dulaney, John F. Grossenbach, both of Huntington; and T. H. Gillman, Ashland, Ky.

THE EVERLASTING ROOF TILE CORP., Brooklyn, N. Y., has been incorporated with a capital of $50,000, to manufacture clay roofing tile and other burned clay products. The incorporators are N. N. Payne, D. J. Horigan and T. P. Killilea. The company is represented by Fitzgerald, Stapleton & Mahon, 25 Broadway, New York.

THE FRYE CHEMICAL Co., INC., Montclair, N. J., has been incorporated with a capital of $50,000, to manufacture chemicals and affiliated products. The incorporators are Walter T. Lindsay, John A. Bennett, and A. C. Kotze, 460 Bloomfield Ave., Montclair.

THE MISSISSIPPI OIL Co., Wilmington, Del., has been incorporated under state laws with capital of $2,000,000, to manufacture petroleum products. The company is represented by the Corporation Trust Co. of America, du Pont Bldg., Wilmington.

THE GREAT EASTERN CHEMICAL Co., Wilmington, Del., has been incorporated under state laws with capital of $50,000, to manufacture chemicals and chemical byproducts. The company is represented by the Colonial Charter Co., Ford Bldg., Wilmington.

THE SOUTH BEND OIL REFINERIES, INC., South Bend, Ind., has been incorporated with a capital of $100,000, to manufacture refined oil products. The incorporators are W. J. Kennedy, Karl G. King and J. L. Nolan, all of South Bend.

THE SALEM FLINT GLASS Co., Salem, W. Va., has been incorporated with a capital of $10,000, to manufacture glass products. The incorporators are H. L. Bee, B. S. Bischoff and F. R. Davis, all of Charleston, W. Va.

THE VERSIL CHEMICAL Co., New York, N. Y., has been incorporated with a capital of $5,000, to manufacture chemicals and chemical byproducts. The incorporators are H. and M. Spatt and A. L. Lazarus, 154 Nassau St., New York.

THE ZANTHONE MFG. Co., Philadelphia, Pa., is being organized under state laws to manufacture cellulose products. The incorporators are John C. Dempsey, J. Harold Felton and Frank Devlin. Application for a state charter will be made on Dec. 12. The company is represented by Porter, Foulkrod & McCullagh, 1106 Commonwealth Bldg., Philadelphia.

THE TRINITY RUBBER PRODUCTS Co., 35 Drift St., New Brunswick, N. J., has been incorporated with a capital of $25,000, to manufacture rubber products. The incorporators are Charles H. Durham, Ernest L. Daniels and John F. Westburgh.

THE SEYDEL CHEMICAL Co., Nitro, W. Va., has been incorporated with a capital of $1,500,000, to manufacture chemicals and allied products. The company is headed by Herman Seydel, head of the company of the same name now operating at 86 Forrest St., Jersey City, N. J., and Richard S Bicknell, Nitro.

THE SECURITY PETROLEUM & REFINING Co., New York, has been incorporated under Delaware laws with capital of $100,000, to manufacture refined oil products. The company is represented by the United States Corporation Co., 65 Cedar St., New York.

Coming Meetings and Events

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE will hold its seventy-fourth meeting at Toronto, Canada, Dec. 26 to 31, 1921.

AMERICAN CERAMIC SOCIETY will hold its twenty-fourth annual meeting at St. Louis, Feb. 27 to March 2, 1922.

AMERICAN CHEMICAL SOCIETY will hold its spring meeting at Birmingham, Ala., April 4 to 7, 1922.

AMERICAN ENGINEERING COUNCIL will hold its next meeting in Washington, Jan. 5-6.

AMERICAN FOUNDRYMEN'S ASSOCIATION will hold its next convention and exhibit at Cleveland, O., during the week of April 24, 1922. Meetings will be held in the spring instead of in the fall as heretofore.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its spring meeting in New York the week of Feb. 20, 1922.

NEW JERSEY CHEMICAL SOCIETY holds a meeting at Stetters Restaurant, 842 Broad St., Newark, N. J., the second Monday of every month.

STAMFORD CHEMICAL SOCIETY, Stamford, Conn., holds a meeting in the lecture room of the local high school on the fourth Monday of each month, except June, July, August and September.

The following meetings are scheduled to be held in Rumford Hall, the Chemists' Club, New York: Jan. 6—American Chemical Society, regular meeting; Jan. 13—Society of Chemical Industry, Perkin Medal; Feb. 10—American Electrochemical Society (in charge), Society of Chemical Industry, Société de Chimie Industrielle, American Chemical Society, joint meeting; March 10—American Chemical Society, Nichols Medal; March 24—Society of Chemical Industry, regular meeting; April 21—Society of Chemical Industry (in charge), American Electrochemical Society, Société de Chimie Industrielle, American Chemical Society, joint meeting; May 5—American Chemical Society, regular meeting; May 12—Société de Chimie Industrielle (in charge), American Chemical Society, Society of Chemical Industry, American Electrochemical Society, joint meeting; May 19—Society of Chemical Industry, regular meeting; June 9—American Chemical Society, regular meeting.